Compressed Air Magazine

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EXAMINING FOUNDATION FOR NORRIS DAM WITH A PERISCOPE-SEE PAGE 4501

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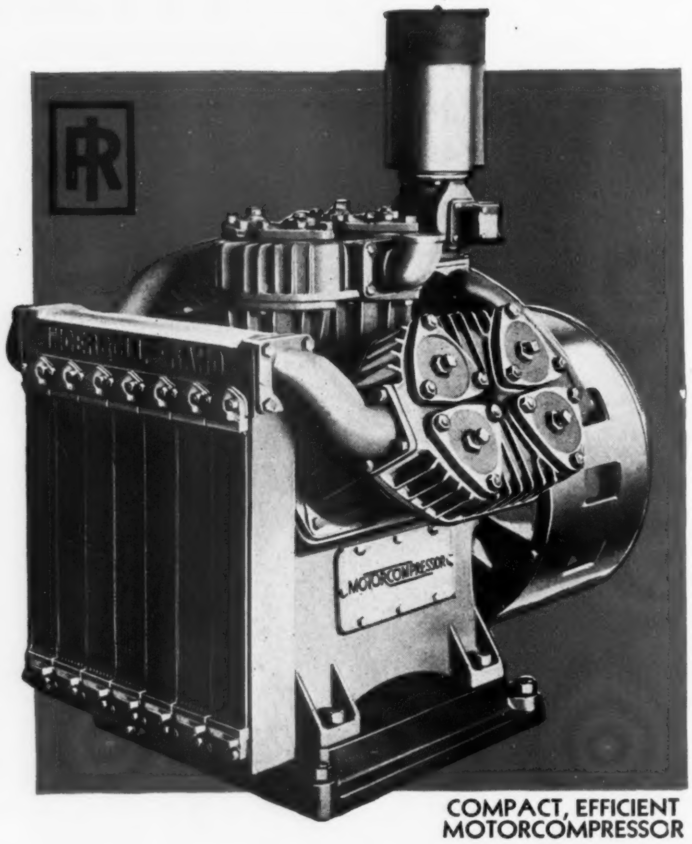

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EDITORIAL CONTENTS

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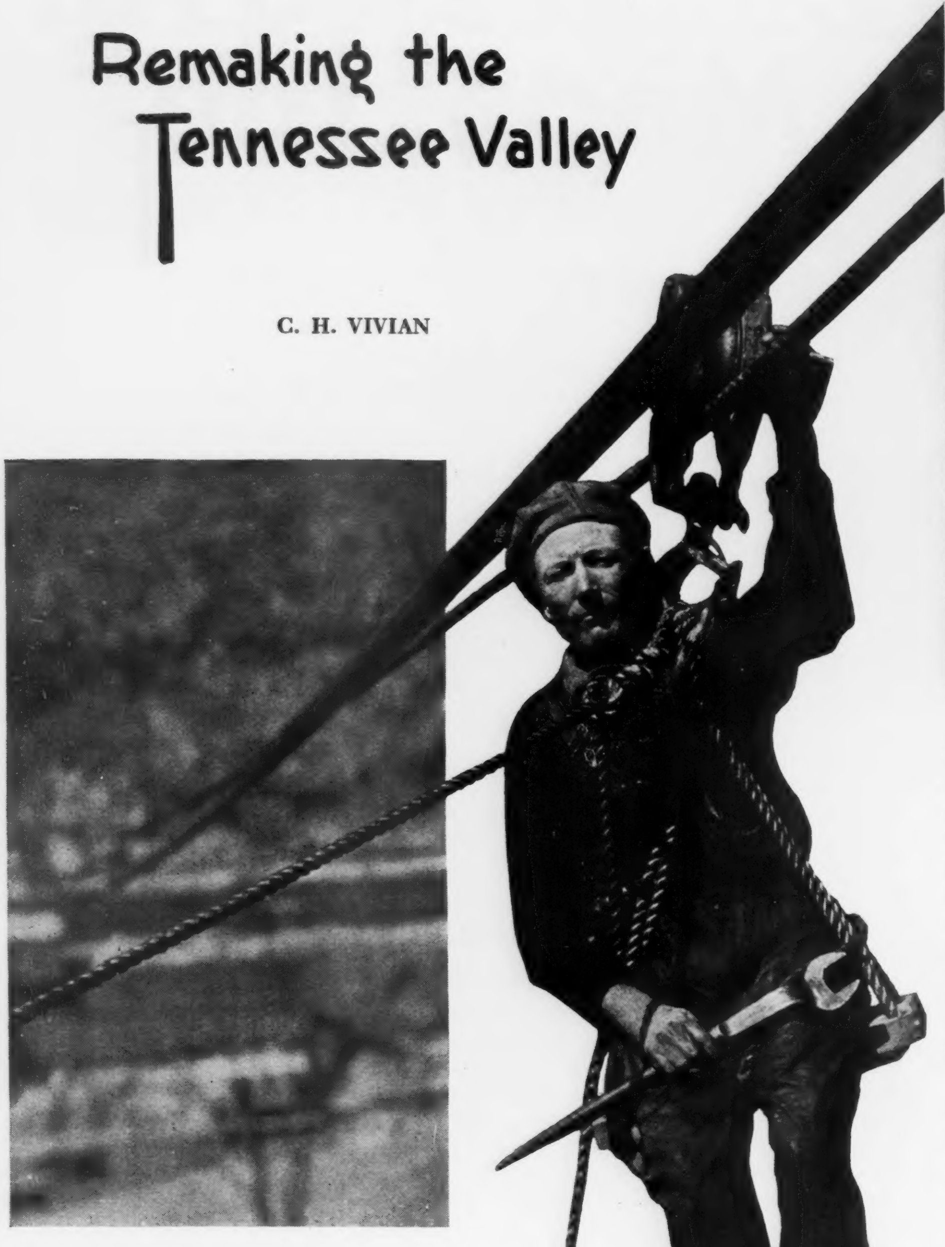
Remaking the Tennessee Valley

C. H. VIVIAN



AS SIMPLY as it can be stated, the aim of the Tennessee Valley Authority is to turn waste into productivity. It contemplates making over some 40,000 square miles of land and readjusting the lives of its residents. It constitutes our first laboratory in national planning. It is frankly an experiment in social and industrial development. If it is successful, other areas of the country will likely be treated similarly. It is a movement of such a vast and ramified nature that it cannot be briefly explained. It is not, however, so mysterious or so nebulous as it is sometimes represented to be. In essence, it is extremely simple; but it has so many parts that the putting of them together into a unified scheme is apt to be confusing.

When white men first colonized the Tennessee River Valley, it was potentially one of the richest sections of the nation. The land was fertile, and there was abundant rainfall to nurture crops. The hillsides were covered with fine stands of timber. Beneath the mantle of soil lay coal and other useful minerals. The numerous tributaries of the river, tumbling down from the Great Smoky and Cumberland mountains, harbored a huge store of energy and combined to form a broad stream which was navigable for small craft throughout most of its course. The climate was equable. Nature had been kind to the region.

TVA NUMBER

Unfortunately, however, the white man did not take good care of his heritage. Today there are 2,000,000 people in the valley. Some of them are wealthy, but far more of them are extremely poor. There are some large cities and some thriving industries, but there are also many scenes of desolation. There are some fine homes and stately public buildings, but there are also thousands of shacks and many deserted farms. In short, there has been much misuse of the splendid natural resources which abounded.

From the earliest settlers on down to the present generation, the people have made that common American mistake of believing that Nature was regenerative. They have taken away without putting back. They have exploited to the point of despoliation. There has been wholesale waste, and the country shows it. The land is far poorer now than it was when Daniel Boone first surveyed it. In the beginning, great lumbering operations feasted upon the wooded hillsides. Thriving towns sprang up, only to dwindle and fall into ruin when the timber grew sparse. No effort was made at replanting. In the wake of the lumbering

NORRIS DAM SITE

An aerial view, looking upstream at the construction area soon after operations had begun. The dam will rise 253 feet above its foundations. To the right are shown drillers with a "Jackhamer" about to descend a shaft in the river through which the first exploration work at the site was done. On the opposite page is a rigger seated in a bosn's chair high above the Clinch River helping assemble one of the cableways which are transporting concrete.

crews came farming people. They planted the cleared land, and for generations Nature was bountiful, and they prospered.

But again there was no attempt to replenish the soil with those elements which it requires to foster continued growth of good crops. Moreover, the stripping of the timber and the cultivation of the sloping hillsides left the land at the mercy of falling rain, and much of the rich top soil began to flow away. Corn always has been a leading crop in these mountain sections, and its method of cultivation leaves the ground particularly susceptible to the action of water. As a result of these things the streams, which were once crystal clear, now run an opaque yellow. There are great patches of barren, gullied slopes, remindful of the Bad Lands of South Dakota and Wyoming. Unless corrective measures are taken, the verdure will entirely disappear and great sections of once fertile countryside will lay in utter ruin, repeating the pathetic story that has been written upon the landscape in certain parts of Greece, Palestine, and China.

Meanwhile, the families that stick to these subproductive mountain farms see their already scant incomes decrease year by year as the ground grows continually leaner. Even now, returns are unbelievably low. A recent investigation by a faculty member of a southern university disclosed that in one county in this upland region the average cash receipts for each farm aggregated but \$45 in 1933, and \$10 of this sum came from relief funds. Studies of 200 farms situated in four counties in North Carolina revealed that after paying taxes and buying indispensable fertilizer the average cash result of the year's work was \$86. These startling figures cannot be blamed upon the lethargy of the inhabitants. By and large, they are an industrious people. At home they are clean, courteous, and intelligent. Transplanted from their native setting, they show themselves quick to learn and willing to work. Their plight is simply that of the artisan who turns out a poor job because he has been handed poor tools.

This is one side of the waste that has visited the Tennessee Valley. The present generation can be blamed for it but little; the real despoilers of the land are moldering in their graves. It can be argued that these people are not bound to the land. The truth is that thousands of them, especially the younger ones, left their homes during the past ten or twenty years and went to the big cities and industrial centers of the North. They were making their way until the depression came. Most of them then found themselves without jobs, and large numbers of them gravitated back to their homes, adding burdens to already strained family budgets. The inevitable result was a wholesale appeal to public-relief agencies. In some counties, 75 per cent of the residents were receiving support at the time the TVA entered upon its program.

One thing that the TVA proposes to do is to stop further erosion of the land. By building series of small dams in the gullies, the run-off water will be made to fill them up with soil; and vegetation suitable for the purpose, such as the new perennial lespedeza, will be planted on the denuded tracts to help moor the dirt. Areas which are past usefulness for farming purposes will be afforested. A change in farming methods will be promulgated. The planting of corn upon sloping, easily washed ground will be discouraged. By exercising suitable methods of control, the U. S. Department of Agriculture estimates, as a result of actual experiments, that the ero-

CHECKING THE RAVAGES OF EROSION

Denuded of its timber, thousands of acres of sloping land have become so badly washed as to be worthless. The growing of corn has helped the destruction. By constructing small dams, the TVA purposes to let run-off water fill in the gullies, after which suitable vegetation will be planted to retain the soil. Unless erosion is stopped, the dams that are being built will fill with silt. Marginal lands which are unprofitable for farming will be given over to grazing or raising timber. Saner use of the soil is expected to restore some of the wasted natural resources as well as to increase farm incomes.

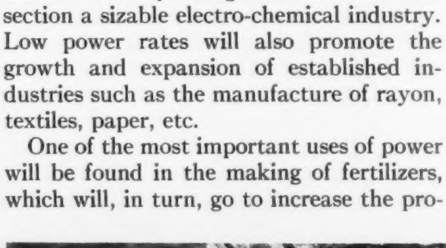
sion can be reduced by 95 per cent.

Another object of the TVA is to provide these mountain people with an auxiliary source of income to help make ends meet. This is to be done by fostering industrial development. It is not intended to create more Detroits, Clevelands, Pittsburghs, and the like. Instead, it is hoped to found numerous small industrial communities within easy reach of the farms and to build networks of good roads over which the workers can travel speedily to and from their homes. The hours of factory work will be controlled to give the employees ample time to take care of their farms. Facilities for vocational training will be provided to permit workers during their idle hours to learn trades or to improve themselves by becoming more proficient in those they already are following. This scheme of coördinating farming and industry is expected to make the mountain people self-sustaining and to minimize unemployment during periods of depression.

The industries which it is intended to encourage are those that already have a foothold in the valley, those that are particularly suitable for the section because of the existence of the necessary raw materials, and those that may be attracted by reason of inexpensive power. This mention of power brings up one of the much-discussed features of the TVA development. The generation of hydro-electric power is one of the important objects of the movement, but it is not the primary object. As can be gathered from the foregoing discussion, and as will be further explained, the production of electrical energy is but an incidental phase of the entire program.

Coal, copper, iron, limestone, bauxite, feldspar, phosphate, zinc, marble, asbestos, kaolin, manganese, and other minerals are found in large or small quantities in the valley. From these natural resources many commercially valuable products can be made by electrical processes. Accordingly, there is already being envisioned for the section a sizable electro-chemical industry. Low power rates will also promote the growth and expansion of established industries such as the manufacture of rayon, textiles, paper, etc.

One of the most important uses of power will be found in the making of fertilizers, which will, in turn, go to increase the productiveness of the land. The fertilizer plants will be operated by the Government. At the present time, extensive researches are being conducted looking towards the development of processes both for the fixation of atmospheric nitrogen and for the utilization of phosphates in making the newest kinds of concentrated fertilizers.



MOUNTAIN WASHDAY

The Stooksbury family performing the Monday morning ritual. Most of the mountain folk occupy homes which have come down to them through several generations. The stock is remarkably pure, only one person in 400 being foreign born.

Although it is expected that there will ultimately be a considerable block of electrical energy available for industrial purposes, emphasis is placed on the fact that first consideration will be given the requirements of home users. The sponsors of the TVA believe that, given a low charge per kilowatt-hour, the people can be prevailed upon to make widespread use of electricity. In view of what has been said about the poverty of some of the people, it may seem doubtful that they can be attracted by such a scheme; but it should be borne in mind that it is also intended to increase the average family income by affording industrial employment and by introducing better farming methods which will raise the returns from each acre.

As it was realized that electrical appliances—refrigerators, stoves, water heaters, washing machines, water pumps, etc.—at the prevailing prices and under the existing merchandising system were beyond the reach of the average pocketbook, a plan has been devised that will make purchases of such equipment easier. The Electric Home and Farm Authority was organized as an agency of the TVA for the purposes of negotiating with manufacturers of electrical equipment for the production

A GLIMPSE OF NORRIS TOWN

Four miles from Norris dam site, a town for 500 families is being constructed on a tract of 2,500 acres. Houses contain from two to seven rooms, are of distinctive architecture, and embody many new ideas. Steel-frame windows, placed in at least two walls of every room, have metal frames and extend to the ceiling line to eliminate trapping warm air inside. Porches are screened in summer, glassed in winter. All houses are heated by electricity and have electric water heaters, ranges, and refrigerators. Unmarried dam workers are quartered in dormitories that have been built there for them.

of standard appliances to sell at reduced prices and of setting up a finance system that will make it possible for the average family to buy those appliances on terms that it can conveniently meet.

This greater use of electrical energy as a household servant is one of the underlying objectives of the entire TVA movement. It is stated that the average domestic consumer in the United States uses only about 50 kw.-hrs. a month. In certain parts of the country such as the Northwest, where current is relatively inexpensive, the consumption is more than double that figure. It would seem, therefore, that all that is necessary to secure a wider use of electricity is to reduce rates. Private companies engaged in the production and sale of power have recognized this, but have contended that they could not grant lower rates until consumers used more of their output. Manufacturers of appliances likewise have insisted that they could not profitably sell their equipment at lower prices unless they were assured a greater volume of business. The situation has resulted in a stalemate, with the consumers waiting for prices to come down and the producers waiting for more business which would enable them to cut prices.

The TVA proposes, then, to increase the use of electricity by reducing its cost as well as that of the equipment which employs it. This brings us to the power-development phase of the program. It goes without saying that the private power companies have utilized the hydro-electric potentialities of the Tennessee River and its tributaries to a considerable extent. As a matter of fact, approximately 25 plants are now producing in excess of 600,000 kw. from falling water. Some of these, owned by large industrial concerns, generate current solely for their own use; but the startling fact remains that the utilities are already developing from 30 to 40 per cent more energy than the consumers demand. In view of this situation it may well be asked: How does the TVA expect to sell vast blocks of additional power, and, moreover, to sell it at prices considerably lower than those that now prevail? The answer involves a consideration of the physical make-up of the Tennessee River and of the plan under which the TVA intends to develop it. As it is intimately connected with the same subject, we may also well ask and answer the question: Why was the Tennessee Valley selected for this undertaking?

TYPICAL MOUNTAIN HOME

A cabin that was removed to make way for the Freeway, a road that will cross the crest of Norris Dam. The clapboard shingles of native homes are being used in the construction of many of the dwellings in the Town of Norris.

From the point where the Holston and French Broad rivers come together 4½ miles above Knoxville in the east-central part of Tennessee, the Tennessee River flows southwest, west, and north through portions of Tennessee, Alabama, and Kentucky, emptying into the Ohio River at Paducah, Ky. It is 652 miles long and has a fall of about 500 feet. The principal cities in the basin are Chattanooga and Knoxville, both of which have populations of more than 100,000 persons.

About 25 years ago, the Tennessee River Improvement Association was formed in the lower basin for the purpose of furthering the improvement of the river for navigation. As previously stated, the stream was navigable in most places, but there were shoals at some points and also considerable stretches where the controlling depth at low water was not sufficient for the passage of barges of economical size. Although it was realized that such improvement would, in all probability, call for the construction of a few dams and, accordingly, make possible the generation of electricity, the power element was entirely a secondary consideration. Neither did the sponsors of this movement have any idea, in the beginning, that the Federal Government might be the agency which would eventually carry out the projected program. On the contrary, efforts were centered upon interesting private capital

to construct the locks, canals, and other structures essential to the creation of a continuous navigable waterway.

This improvement association, which was strictly an independent organization composed of citizens of the lower basin, succeeded in bringing about the deepening of the channel as far upstream as Muscle Shoals, Ala., a few miles south of the Tennessee state line and 260 miles from the mouth of the river. From Brown's Island to Florence, Ala., shoals or rapids extended for a distance of 37 miles, and in this stretch the river dropped 134 feet.

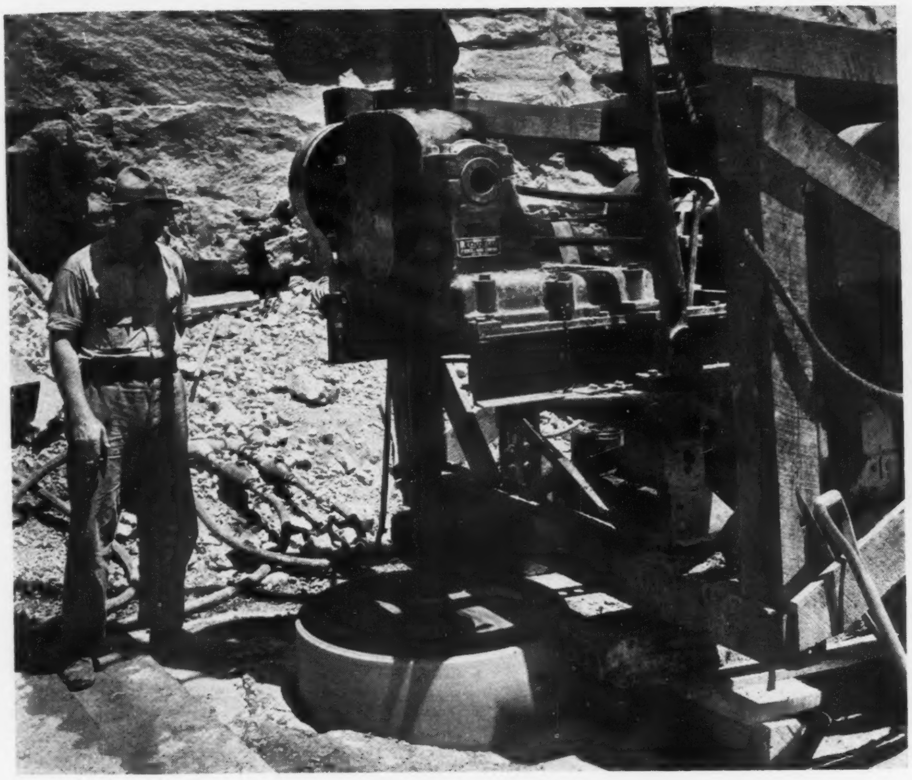
At this juncture the World War came on, and the Government sought a location where it might produce nitrates for use in the manufacture of explosives. This process involved the fixation of atmospheric nitrogen and called for large quantities of electrical energy, making it desirable to find a site where power might be developed inexpensively by utilizing falling water. Realizing that the upper reaches of the Tennessee River and its tributaries contained numerous potential locations for such a plant, the people of the upper basin, including Chattanooga, and more especially Knoxville, began a concerted movement to interest the War Department in that section. Almost immediately, however, they came face to face with the fact that the lower-basin interests had, during the course of their efforts to improve navigation, prepared extensive engineering data looking towards the construction of a dam at Muscle Shoals, with the result that this site immediately gained preference. They accordingly decided to throw in their lot with the lower-basin interests in the campaign for the selection of Muscle Shoals. In return, they received assurance that the lower basin would coöperate with them in a further movement to promote the development of the upper stretches of the river.

In furtherance of this agreement there was raised between 1920 and 1926 a total of $250,000, and this money was used in laying before Congress information regarding the potentialities of the Tennessee River Valley for power and navigation development with a view to securing Federal funds for the desired improvements. This movement was successful, and resulted in Congress appropriating over a period of a few years an aggregate of $1,106,000 for surveys. Those studies were designed to show not only the possibilities of the river for power and navigation purposes but also involved an investigation of the mineral and other resources of the valley that might be developed to insure the maximum use of the proposed works.

CONSTRUCTION ROAD, AND DAM BUILDERS

To provide a means of moving supplies to the Norris Dam site, grading for a 4.8-mile, heavy-duty highway from Coal Creek was completed and one strip of concrete laid in 69 days. The two men at the top of the page are in immediate charge of work at Wheeler Dam. They are: Lee H. Huntley, construction superintendent, on the left; and W. M. Hall, construction engineer. At the bottom of the page are shown Ross White, construction superintendent at Norris Dam, on the left; and C. H. Locher, consultant to the TVA on dam construction.

Detailed engineering investigations of the river were made by U. S. War Department engineers. A report summarizing this work was transmitted to Congress on March 24, 1930. It consisted of a volume of 734 pages in addition to a large number of maps, and constituted the most thorough and exhaustive document of its kind ever presented to our Government. This report considered the improvement of the river from the standpoints of navigation, flood control, power development, and irrigation. It contained complete preliminary engineering data and cost estimates for the construction of dams, locks, and other structures which would be required to provide a 9-foot channel from the mouth of the river to Knoxville and a minimum 6-foot channel for a considerable distance up all the major tributaries. Various possible plans for hydro-electric generating plants in conjunction with the navigational features were outlined—the amount of the potential power and its cost being shown to vary according to whether low or high dams were to be erected at particular



SAMPLING A DAM FOUNDATION

A "Calyx" core drill extracting a 36-inch section of the rock on which Norris Dam will rest. Holes of this size have been drilled to depths up to 50 feet at various points in the excavation area to enable Dr. Charles P. Berkey, geologist, to scrutinize the underlying structure. The core also furnishes a record of the formation.

points and whether certain auxiliary steam stations were to be built.

This report estimated that it would be necessary to spend $1,200,000,000 to provide for the maximum ultimate use of the waters of the Tennessee Basin. All told, the projected plan of development included 149 hydro-electric plants. It was estimated that by creating storage reservoirs which would make it possible to equalize the flow of the river there could be developed about 3,000,000 kw. of firm or constant power at an average cost of 4⅓ mills per kw.-hr. at the bus bars of the stations. In his letter of transmittal, Maj. Gen. Lytle Brown, chief of engineers of the War Department, stated that "while this price is not remarkably low for a large hydro-electric power development, it is considered sufficiently low to constitute an economically feasible and desirable project whenever the demand for power has grown sufficiently to produce a market which could absorb such large quantities."

During the years in which these studies were in progress, the Muscle Shoals development had become a national white elephant. The first nitrate plant built there was obsolete before it was finished, and the second one was not completed until the closing days of the war. It was operated only long enough to prove that it would do what it was designed for. The dam itself, which had been named Wilson Dam after the wartime president, and the power houses in connection with it, were not finally completed until September, 1925. Meanwhile there had been a considerable movement in Congress to authorize Government operation of the Muscle Shoals development. Ultimately, bills sponsored by Senator George K. Norris of Nebraska, its leader, were twice passed by Congress, but in each instance they were vetoed, once in 1928 by President Coolidge and again in 1931 by President Hoover. Offers from Henry Ford and from other private interests to lease or to buy the Muscle Shoals development had been rejected previously by Congress. All this time the nitrate plants remained inactive except for the period already mentioned. Today, a demonstration plant for the production of phosphate fertilizers is being built at Plant No. 2 and will be ready for service soon; and the power house is developing electricity which is being sold directly to municipalities by the TVA. Until the TVA took over the operation of that plant the Government was selling some current at two mills a kilowatt to private utilities which retailed it to consumers at a higher figure.

With this background in mind it is easy to see why the Tennessee Valley, and not some other section of the country, was selected for the notable project which is now underway. It is evident that even before President Roosevelt entered office he had made an intimate study of the situation in the valley and had determined that it presented an opportunity to test some of his theories. On April 10, 1933, scarcely a month after his inauguration, he sent to Congress a message proposing the creation of the Tennessee Valley Authority. On that occasion he said: "The continued idleness of a great national investment in the Tennessee Valley leads me to ask the Congress for legislation necessary to enlist this project in the service of the people. It is clear that the Muscle Shoals development is but a small part of the potential public usefulness of the entire Tennessee River. Such use, if envisioned in its entirety, transcends mere power development: it enters the wide fields of flood control, soil erosion, afforestation, elimination from agricultural use of marginal lands, and distribution and diversification of industry. In short, this power development of war days leads logically to national planning for a complete river watershed involving many states and the future lives and welfare of millions. It touches and gives life to all forms of human concerns.

"I, therefore, suggest to the Congress legislation to create a Tennessee Valley Authority—a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise. It should be charged with the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory for the general social and economic welfare of the nation. This authority should be clothed also with the necessary power to carry these plans into effect. Its duty should be the rehabilitation of the Muscle Shoals development and the coördination of it with the wider plan. Many hard lessons have taught us the human waste that results from lack of planning. Here and there a few wise cities and counties have looked ahead and planned. But our nation has 'just grown.' It is time to extend planning to a wider field, in this instance comprehending in one great project many states directly concerned with the basin of one of our greatest rivers."

Senator Norris introduced the bill embodying these recommendations. It was speedily passed by Congress and became a law when President Roosevelt signed it on May 18. It became operative 30 days later. The TVA is, as the President suggested it should be, a corporation with governmental powers but with the "flexibility and initiative of a private enterprise." Its management is in the hands of three directors appointed by the President with the approval of the Senate. These directors are: Dr. Arthur E. Morgan, former president of Antioch College, Ohio, and a well-known engineer who directed flood-conservation work at Dayton, Ohio, and at Pueblo, Colo.; Dr. H. A. Morgan, who was granted a leave of absence from his duties as president of the University of Tennessee to take up his new post; and David E. Lilienthal, a Chicago lawyer.

A LAGGARD THAT MUST GO TO WORK

Wilson Dam, part of the Government's $150,000,000 wartime investment on the Tennessee River, which has been taken over by the TVA as the nucleus of a huge power-development project. The dam is nearly a mile long. The power house in the foreground contains generators having a capacity of 261,000 hp., and room is available for increasing the installation to 612,000 hp. The structure is at the foot of Muscle Shoals, a 37-mile stretch of rapids probably originally named "Mussel Shoals" because of the occurrence there of fresh-water mussels. The dam forms a lake 15½ miles long, extending upstream to Wheeler Dam site.

The scope of the activities of the TVA is detailed at considerable length in the Norris Bill. In places the provisions are explicit. Elsewhere only a general plan is outlined and the directors must devise ways and means of action. Boiled down, the general program includes the generation of power; the building of dams, power plants, and transmission lines; the development of fertilizers; and, under the immediate direction of the President, a program of social and economic planning with the aim of promoting the social and economic welfare of the region and of the nation. The latter phase of the activities includes soil erosion, forestry, the balancing of agriculture and industry, the better and fuller use of mineral resources, and such problems as the vocational adjustment of unemployed men and women through the creation of new or more productive fields of work.

The Authority immediately took over Wilson Dam and its power plant. It is proposed that the operation of this property, together with the transmission of the power generated there, shall constitute "a yardstick in determining the relative costs of public and private power operation." Distribution of power has already started—Tupelo, Miss., having been the first municipality to receive it. Several other cities, the largest of them Knoxville, have voted to purchase Muscle Shoals power. Total earnings of the dam in 1933 were $580,000. Official estimates are that these will be increased under TVA operation to $780,000 in 1934.

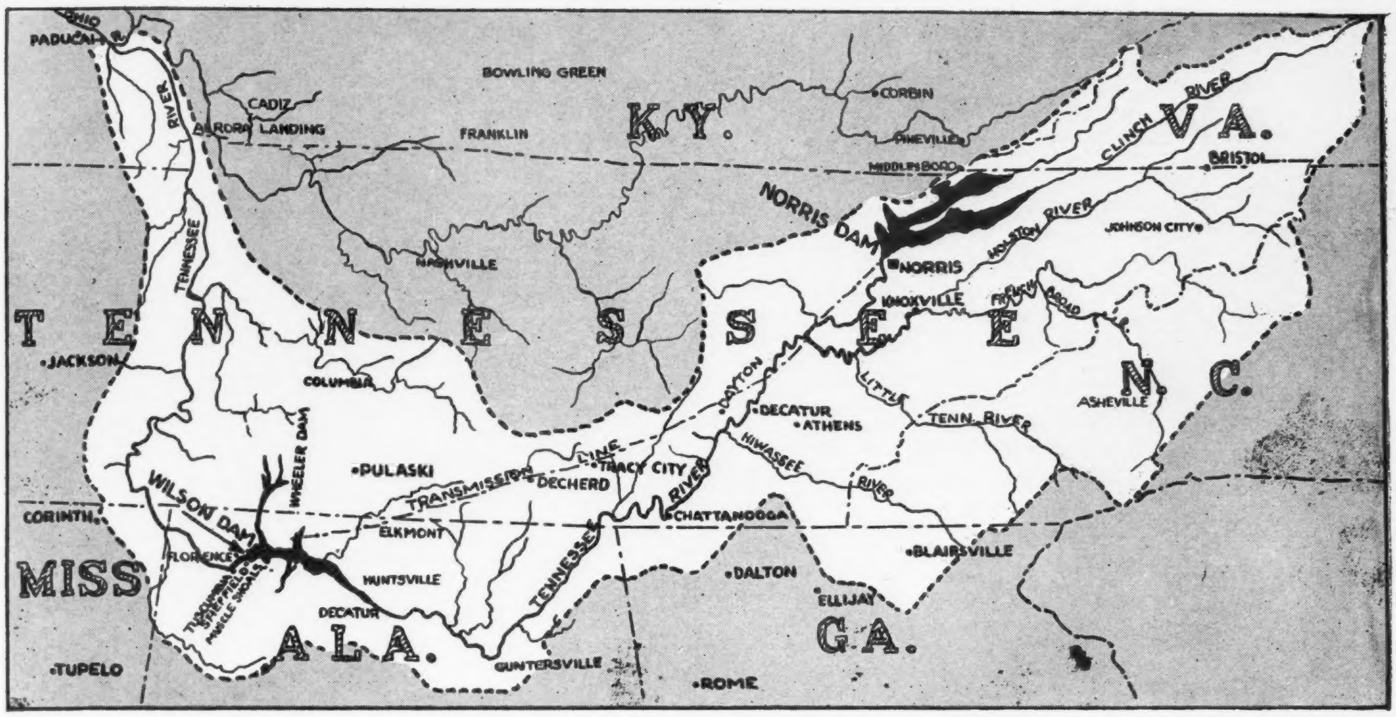
When the TVA came into being, it had at its command the comprehensive War Department program for the development of the river that we have previously mentioned. In the main, the plan outlined there is being followed. We find in it an answer to our question as to how the Government hopes to generate electricity at a cost that will permit it to supply current to consumers at materially lower rates than they are now paying for it. The explanation lies in the fact that it is intended to erect a sufficient number of dams to control the river's flow closely and thereby to make available at all times the maximum volume of water for use at the turbines. The ultimate program will require many years for completion. Thus far, construction has been started on two dams, which will be discussed presently.

When the TVA was created it was given an initial appropriation of $50,000,000 with which to work, and was also accorded the power to issue bonds up to $50,000,000 as a means of securing additional funds. It is purposed, however, not to exercise this right except in case of emergency, and to call upon Congress for continuing appropriations as they are required. An additional sum of $48,000,000 was provided in the deficiency appropriation bill which was passed by the last Congress in the final days of its session. Actual disbursements up to May 15 were $6,865,000. Offices were established at Knoxville, Tenn., where, at the present time, there is a total staff of approximately 700 persons occupying parts of three office buildings. All told, about 9,500 employees are at work, and of these about 4,000 are engaged in clearing reservoir sites for the two dams that are now underway. It is estimated that work will be available for 20,000 persons when operations reach their height.

The general plan for developing the power resources of the river contemplates the construction of dams designed for two different purposes. In the lower sections there will be "run-of-the-river" dams where all the available falling water will be utilized for turning turbines. The first of these, the Wheeler Dam, is now being built at the head of the slack water formed by Wilson Dam. The second class of dams will be for the primary purpose of storage, although some generating equipment will be provided in connection with them. The latter will be located on tributaries of the Tennessee. They will store water in seasons of high flow and will release it during periods of low flow in order that it may be used to generate power at the run-of-the-river plants downstream. This balancing of the river flow throughout the

COMBINING EDUCATION AND WORK

An interior view of the trades school, a part of the extensive facilities provided at the Town of Norris for the training of employees at Norris Dam. The men work only 5½ hours a day, allowing ample time for instruction.



GENERAL MAP OF THE REGION

The Tennessee is the fifth largest stream in the United States. Its basin contains approximately 40,000 square miles and has 2,000,000 inhabitants. The section shown in white represents the sphere of the TVA activities.

year will tend to level the peaks of high and low production of power and increase the total of the firm or continuous horsepower available. Norris Dam, named for Senator Norris and now under construction on the Clinch River above Knoxville, is the first dam of the storage type.

In reporting upon the first year's work of the TVA, Dr. A. E. Morgan, chairman of the organization, told a Congressional committee that it is planned in the course of the next five years to spend $310,000,000. Aside from the initial $50,000,000 appropriation, this sum is to be allocated approximately as follows: $72,000,000 in 1935, $56,000,000 in 1936, $41,000,000 in 1937, $45,000,000 in 1938, and $40,000,000 in 1939. He also disclosed that it is the expectation to build four additional dams during that period. Two of these will be run-of-the-river structures on the lower Tennessee, while the other two will be of the storage type on tributaries. The estimated cost of the four structures is around $130,000,000. One of them, to cost $42,000,000, may be located at Aurora Landing, Ky., 43 miles upstream from the point where the Tennessee empties into the Ohio. The second of the lower-basin dams may be at Pickwick Landing, Tenn., 206 miles above the mouth of the river. Its cost is placed at $39,000,000. One of the storage-type dams will be situated somewhere on the Hiwassee River which flows into the Tennessee about 35 miles above Chattanooga. Its estimated cost is $13,000,000. The other storage dam is suggested for the French Broad River, and is listed to cost $30,000,000.

The general plan of procedure is to construct the dams progressively in order that much of the equipment purchased for the initial structures can be used on those to follow. There is some variation in the equipment as between the two types of dams. For example, floating concrete mixers which will be employed on the Wheeler Dam on the lower basin can, in turn, be used on the Aurora and Pickwick Landing projects. Similarly, traveling cableways required for placing concrete on the Norris Dam can be utilized at the French Broad and Hiwassee sites.

According to Doctor Morgan, the program thus far outlined calls for the construction of seven dams, although others may ultimately be built in conformity with the comprehensive scheme drawn up by the War Department engineers. He estimates that those seven dams with their appurtenant generating stations will be able to produce from 750,000 to 1,000,000 kw. of primary or continuous power and, possibly, 1,000,000 kw. of secondary or intermittent power. It is his belief and hope that such a unified system for controlling the flow of the river will make it feasible to generate power at about half the present cost of that developed at Muscle Shoals. If this can be done, he predicts that the rates to consumers will be sufficiently low to attract a market for all the power that will be produced.

All the dams projected for the 652-mile stretch of the main Tennessee River will be provided with navigation locks. It is unlikely that the War Department program for navigational facilities on the major tributaries will be carried out in its entirety. No lock is being built in the Norris Dam, as previously contemplated.

In addition to constructing power plants and transmission lines, the TVA has authority to negotiate with private power companies for the exchange of current and for the acquisition of any of their properties that will fit in with the broad general plan as it develops. The only private hydro-electric project on the main course of the Tennessee River is the Hales Bar Dam a few miles below Chattanooga. This is owned by the Tennessee Electric Power Company, and has an installed capacity of 54,240 hp. It was completed in 1913 at a cost of approximately $11,000,000. In conjunction with it the company operates a steam-generating station which has a capacity of 53,620 hp. While no official announcement has been made on the subject, Doctor Morgan has expressed the opinion that the TVA ought to own and operate all the hydro-electric plants on the river, and this is taken to mean that there is a possibility of the Hales Bar plant being acquired.

It is impossible, in the space available, to discuss completely the manifold phases of the TVA activities. Some of them have not been mentioned, and others have been only briefly outlined. As our readers are primarily interested in the construction features of the undertaking, it is our intention to devote the major portion of our description to them. Accordingly, in the following articles, we present accounts of the current work at the Norris and Wheeler dam sites.

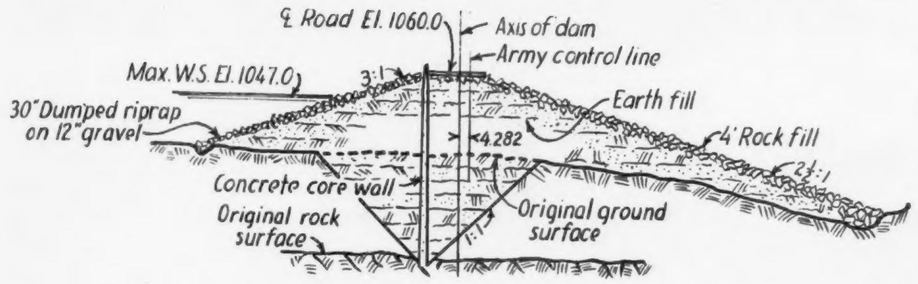
WHEN DARKNESS FALLS

As Cy Warman wrote of the boom camp, Creede, there is no night at Norris Dam. A concentration of illumination over the working area enables the operations to go on as efficiently after dark as before. This view was made looking across the cofferdam from the east abutment. Surprinted on the base of the halftone is a sketch showing the downstream elevation of the dam.

Building Norris Dam

THE first major construction undertaking of the TVA to get underway is Norris Dam, which is being built on the Clinch River some twenty miles northwest of Knoxville and about 80 miles above the confluence of the Clinch and Tennessee rivers. It is 228 miles upstream from Muscle Shoals. In the point of the area which it drains—4,400 square miles, the Clinch is the second largest of the tributaries of the Tennessee River system. The French Broad River, with a drainage area of 5,140 square miles, is the only one that exceeds it. The Clinch rises in Virginia and flows southwest through a mountainous and relatively sparsely settled region. A few miles upstream from the dam site it is joined by the Powell River, a lesser stream which also rises in Virginia a short distance north of the Tennessee line and close to the divide which separates the Tennessee and Cumberland river systems, both of which eventually empty their waters only a few miles apart into the Ohio River.

Norris Dam will be the first of the several high dams on the headwaters of the Tennessee River whose primary function will be to regulate the river flow for the dual purpose of increasing hydro-electric-power production and of reducing the flood hazard. Two generating units of 66,000 hp. capacity each will be installed at Norris Dam, but ordinarily they will be operated only during the season of low flow on the Tennessee. The dam was planned for a height sufficient to impound a normal year's run-off of the Clinch River. The total capacity of the reservoir—including dead storage, power storage, and flood storage—is 3,600,000 acre-feet. It is expected that during the winter, when water is plentiful in the main stream below, little or no water will be allowed to pass the dam, and its power plant will be used as an emergency standby and for voltage regulation. During the summer, when the Tennessee is ordinarily low, the stored water will be released through the turbines of the Norris Dam power plant and made useful at the run-of-the-river power plants below, thereby helping to flatten out their



TYPICAL EARTH-FILL SECTION

production curves—that is, to raise the firm or continuous output of the system.

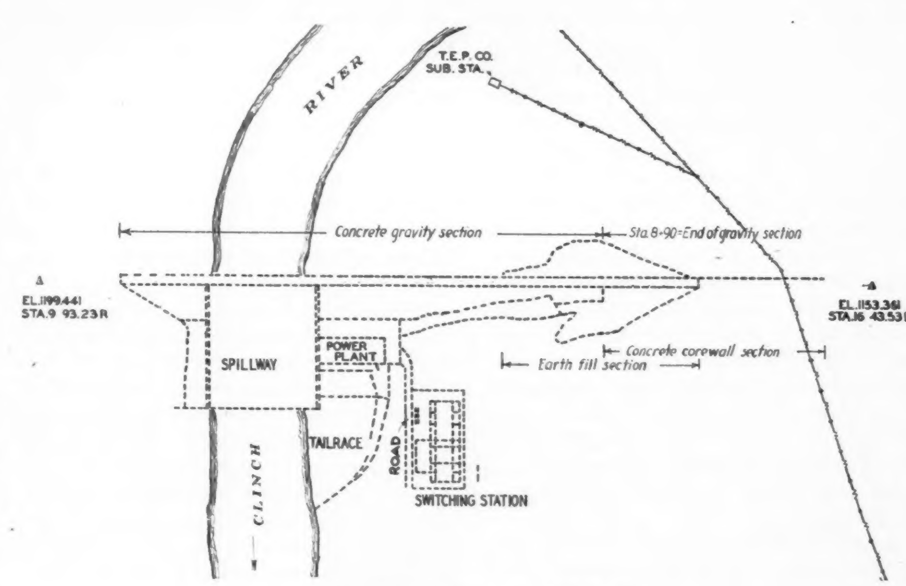
Flood control is of particular importance to Chattanooga, and will be helpful in a lesser degree to Florence, Ala., Johnsonville, Tenn., and other downstream points. High water causes average annual damage of $1,780,000 along the river, according to army engineers who have kept records of the stream flow since 1875. Flood stage—the depth at which damage starts—is 33 feet at Chattanooga, where flood costs average $687,000 yearly. In 1867, the river reached 57.7 feet, causing extensive destruction. It is estimated that Norris Dam alone, had it been available at that time, would have reduced the flow to 32.7 feet, a comparatively harmless level.

The mean annual rainfall of the Tennessee River Basin is 51.2 inches. Of this, 16 inches quickly runs off by way of the streams and 35.2 inches enters the soil. However, only 6.4 inches of the latter penetrates to the deep storage reservoirs of the ground to feed springs and to maintain river flow during dry periods. The other 28.8 inches is lost through transpiration and evaporation. It is established that ground storage can be materially increased by erosional control work and reforestation; and these two activities of the TVA may therefore be classed in part as flood-relief measures.

The army engineers studied approximately 200 possible dam sites in the Tennessee Valley. From stream gauging data and other sources of information they determined that of all the prospective high dams the first one should be located where Norris Dam is now taking form. The annual flow of the Clinch is not so great as that of some of the other tributary streams, but no other site was found where a dam of the given height would impound a corresponding volume of water on reservoir land of equally low value. Accordingly particular attention had been given to this location and a great amount of preliminary engineering work done before the TVA came into existence. As a matter of fact, the War Department sent three field parties there on April 3, 1933—fifteen days before the Norris Bill was passed, to make final surveys preparatory to starting work. All these accumulated data were made available to the TVA when it took over the project on June 18, and, as a result, only a short time was required to complete the plans and to begin active construction. It should be mentioned here, incidentally, that the final design and plans were prepared by the Bureau of Reclamation at its Denver office. In this the bureau exhibited the same expedition and thoroughness as it did in the case of the engineering work for Boulder Dam. The plans adhere closely to the previous tentative designs of the army engineers, save for the elimination of a navigation lock which had been included before and a change in the type and location of the spillway. In the army scheme of the Tennessee River development this structure was designated as the Cove Creek Dam because its site is a short distance below the point where Cove Creek flows into the Clinch River. The name was changed in recognition of Senator Norris's 16-year fight for public utilization of the power resources of the Tennessee Basin.

It is estimated that Norris Dam power house and reservoir will cost approximately $34,000,000, and that it will be finished in three years. One of the largest items of expense is that incurred in the acquisition of land which will be inundated by the reservoir. The artificial lake to be created will cover about 83 square miles and, because of its extremely irregular shape, will have a shore line of approximately 800 miles. The reservoir site was made up of some 3,500 different parcels of land constituting the homes of about 1,500 families. In most cases agreements on price are being reached without much difficulty. Some of the families affected have made their homes in this mountain fastness for generations, and they were reluctant to leave and face the necessity of readjusting themselves in other locations. In taking over the reservoir area the TVA showed them every consideration. An instance of this was the agreement to reinter all bodies buried there. There are upwards of 100 cemeteries, containing about 5,000 bodies. For purposes of record, a photograph is taken of each grave prior to exhuming the body. In addition to the land that will be flooded, approximately 20,000 acres of shore land will be purchased for reforestation work by CCC units. All the area within the reservoir site will be cleared, and it is expected that about 1,100 men will be employed in this work. Merchantable timber will be hauled out for use on TVA work or for sale. Trees and other growth which have no commercial value will be cut, dried, and burned.

Norris Dam site is in Anderson County. The nearest approach to it by railroad is Coal Creek, about five miles distant. It was originally intended to build a branch line from that point to facilitate the delivery of machinery and materials—principally sand, gravel, and cement, but this plan was not followed by the Authority. Investigations revealed that a hillside forming one slope of a draw reaching the river just upstream from the dam site contained, beneath a soil overburden averaging 6 feet deep, dolomitic limestone of suitable quality for the making of the 2,000,000 tons of sand and coarse aggregate that will be required for the concrete. It was, accordingly, decided that a heavy-duty highway would suffice for haulage purposes, and one was constructed from Coal Creek at a cost of approximately $260,000. This 4.8-mile road was built in



GENERAL LAYOUT SKETCH

TWO VIEWS OF THE SITE

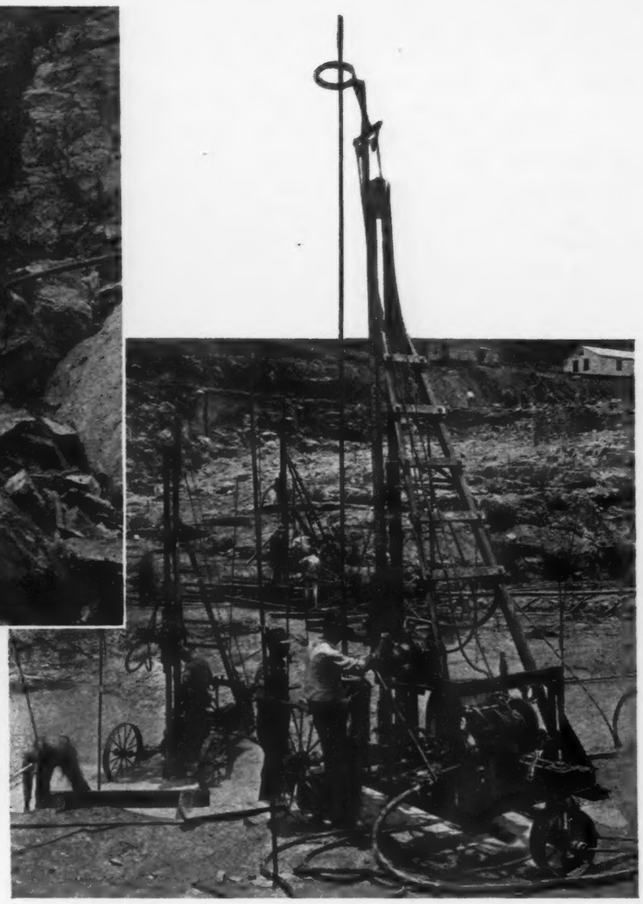
The picture above was made from the east abutment, looking west. The trestle along the far wall at the left supports the railroad which will carry concrete from the mixing plant to a position beneath the cableway head towers. The cleared slope near the top at the right is the quarry site from which rock and sand for concrete aggregates will be obtained. Leading from it to the concrete mixing plant near the top center is the structural steel framework of the conveying, crushing, and screening system. The picture at the right was taken from the opposite direction. The cofferdam is in the foreground. The two parallel lines within it to the left mark the foundation for the gravity section. The right-hand area of the cofferdam is being excavated for the spillway apron.

unusually fast time. W. W. Boxley & Company, of Roanoke, Va., took a contract last fall to provide a usable roadway in 69 working days. By distributing equipment at various points along the line and by utilizing a large force of workmen, this firm, with C. A. Bray directing operations, completed within the specified time grading calling for the movement of 190,000 cubic yards of excavation and laid one 11-foot strip of concrete. This roadway has a ruling grade of 6 per cent and a minimum radius of 300 feet on curves. The paving is 22 feet wide and consists of two strips, each 10 inches thick at the edges and 8 inches at the center, heavily reinforced on filled ground to withstand a load of 20 tons carried on six wheels. All the 1,000,000 barrels of cement which will be required for the dam, as well as the steel, generators, machinery, and other heavy materials, will be transported over this roadway. Much heavy haulage on trailers has already been done without any evidence of settlement in the subgrade.

Norris Dam will be a concrete structure of the gravity type and will have an extension—consisting of a concrete core wall flanked by an earth fill—reaching into the east abutment where the ground has a gradual slope. The west abutment is steep, and the gravity section will be keyed directly to it. The dam will be 210 feet thick at the base and will rise 253 feet from the foundation to the 22-foot roadway which will cross the top 40 feet above the spillway crest. It will be 1,872 feet long at the top, and of this 1,570 feet will be gravity section and 302 feet will be an earth-fill or core-wall section. In addition, the concrete core wall will extend for a distance of 400 feet into the east abutment. The earth fill will have a total length of 630 feet, including an overlap of 325 feet on to the gravity section.

Although the concrete roadway from Coal Creek was not ready for use until early this year, construction at the dam site was started on October 14, 1933. In order that work might proceed with a minimum of delay, as well as for other reasons, it was decided to build the dam by force account rather than by letting a contract. An organization containing some of the foremost construction men in the country was carefully assembled to direct operations. Workmen were recruited from the more than 100,000 persons who had filed applications with the TVA. Preference was given valley men, and a large percentage of those on the payroll live within 25 miles of the job. First attention was given to the building of a construction road down into the valley from a bluff on its west side where the paved road was to end. This highway drops approximately 400 feet in its mile of twisting course. Operations were also started on a bridge across the river at a point about 300 yards downstream from the dam site so as to gain access to working locations and to the areas which were to house shops and other essential structures. This bridge had to be strong enough to bear the weight of power shovels and other large equipment that had to be moved in.

The Clinch River is a fitful stream and, from known records, varies in flow from 200 to 76,000 cubic feet a second. During flood stages it carries big logs and other debris which require large, unobstructed openings for their passage. For this reason, and also because of other conditions, cofferdams were chosen in preference to tunnels as a means of diverting the river during the construction period. The stream channel is at the extreme west side



TWO KINDS OF DRILLING

Although wagon drills are used to break up most of the rock in excavating, "Jackhamers" are also extensively operated. Scalers are seen above cleaning the rock face of the west abutment. At the right is a corner in the spillway-apron section, showing wagon drills putting down holes for grouting.

of the valley contiguous to the relatively steep rock slope, and the first of the cofferdams extends to within 460 feet of the western end of the dam. This cofferdam constituted the first work at the dam site. It is a double, 3-sided, box-type structure of 8x8-inch timber cribs on 10-foot centers. Its upstream and downstream ends extend from the sloping east bank out into the river and average 154 feet in length. The connecting side wall runs riverwise for 500 feet. The timberwork was filled with clay and rock, and has proved suitably watertight despite the fact that the solid-rock river bottom precluded driving piling. Last spring the river rose to a flood stage of 50,000 second-feet without damaging the structure. When the portion of the dam within the first working zone has been built up somewhat above high-water line, the first cofferdam will be removed and the second one built to inclose an area at the west end of the dam. This cofferdam will be higher than the first one, and will serve to back up the water behind the completed section of concrete until it finds an outlet through two gaps which will be formed by placing two of its 56-foot blocks 30 feet lower than the adjoining ones. These gaps will subsequently be filled.

The first cofferdam was unwatered on January 28, 1934, permitting access to the river bottom. Meanwhile, excavating for the foundation had already started on the higher east slope. Throughout the Tennessee Valley, the prevailing bottom rock of the streams is limestone. At Norris Dam it is a dolomite, a closely related rock in which some of the calcium has been replaced by magnesium. It lies in beds which are virtually flat with respect to the east-west direction and which dip a few degrees to the south—the direction of river flow at this point. Preliminary investigations had satisfied the engineers that they would not have to go very deep into this rock to secure a suitably stable foundation for the dam, and subsequent developments have borne out this theory.

The river bottom at the axis of the dam is at elevation approximately 820, and within the cofferdam the excavation for the gravity section was, in places, carried down to elevation approximately 807, a depth of 13 feet. The general method of procedure was to line drill around the area of excavation and then to take out the rock by benching it. Over the spillway-apron area, which is 332 feet wide and about 380 feet long, only sufficient material was removed to gain the desired sloping surface of compact, unbroken rock. The excavation for the power house, just downstream from the dam and adjoining the spillway on the east, was carried down to elevation 792, or about 32 feet below the river bed. The cut in the hillside for the east wing of the dam was made in the form of a series of benches conforming to the stratification and rising by steps as elevation was gained.

Following the stripping of surface material, the rock was drilled for blasting chiefly with wagon drills, there being fourteen of these heavy-duty machines on the job. Near faces that had been line drilled, and in locations that called for easier-handling equipment, "Jackhamers" were employed. The latter type of drills is being used exclusively for stripping the west abutment where the steep slope necessitates suspending the workmen from ropes. As the removal of muck has kept close pace with drilling, blasting is done whenever a sufficient number of holes is loaded. Warning signals are sounded on a compressed-air whistle located on the cofferdam; and at various times during the day everybody seeks cover and work stops while cartridges of 40 per cent dynamite exert their rending influence.

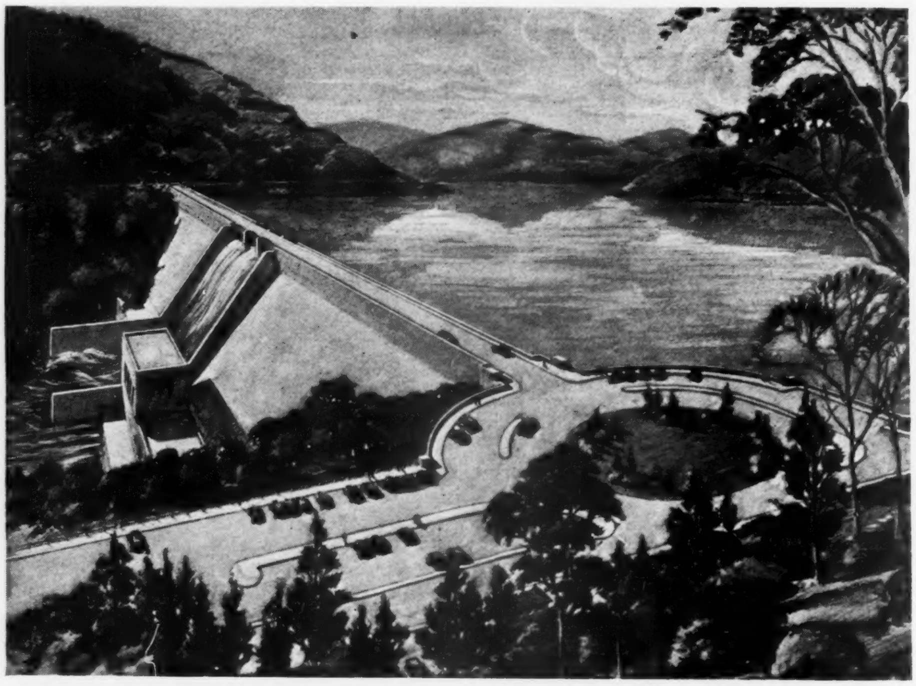
Four power shovels are employed in loading muck. Within the cofferdam, two 3-yard electrics and a Marion and a Bucyrus Erie handle the work. At various other points of excavation, one 1¼-yard Marion gas-electric and a 1¼-yard Lorain gas-driven type are used. Four tractors mounted on crawlers and equipped with bulldozers concentrate the spoil for the shovels. Two of these are Allis-Chalmers 75's; one is an Allis-Chalmers 30; and the other is a Caterpillar 30. Six trucks, having 12-yard steel bodies similar to those employed at Boulder Dam except for the absence of a protective hood over the driver's seat, and two 8-yard conventional-type trucks are used for hauling muck from the cofferdam.

A fleet of smaller trucks serves elsewhere about the job. Up to July 15, the total material excavated consisted of 156,205 cubic yards of earth and 219,065 cubic yards of solid rock. During the early part of the work, some of this material was placed downstream from the dam site on the east side of the river to raise the area for buildings and equipment. Since then it has been dumped within the reservoir area at a point of disposal just upstream from the dam location.

With high ground at both ends of the dam site, physical conditions favor the use of traveling cableways for pouring the concrete, and two of them are provided. These are similar in type and operation to those that have been used so successfully at Boulder Dam. The towers were built by the Virginia Bridge & Iron Company of Roanoke, Va., and equipped by the Lidgerwood Manufacturing Company. They have a clear span of 1,926 feet, each having one 3-inch track cable made up of 169 strands of special steel wire. Each cable weighs 28 tons, has a tensile strength of 550 tons, and a rated load carrying capacity of 18 tons. The two sets of 75-foot head towers and 110-foot tail towers use the same track runways for lateral movement. These consist of two heavy 2-rail tracks spaced 52 feet apart. Head towers can cover 500 feet and tail towers 528 feet, these distances being sufficient to permit placing concrete anywhere throughout the pouring area, including all points of the dam, spillway, and power house. To aid them in resisting the pull upon their tops, the towers are counterweighted with concrete blocks—the tail towers with 446 tons each and the head towers with 388 tons each. The cableways have a traveling speed of 1,200 feet a minute, a hoisting speed of 300 feet a minute, and a lowering speed of 405 feet a minute. Transverse movements of the head and tail towers of each cableway will be controlled from the respective head tower and can be made at the rate of 50 feet a minute. It is expected that the operators stationed in the head towers will depend solely upon signals relayed to them by flagmen and telephones when spotting loads.

The location of the hillside deposit and its relation to the dam and cableway system are very suitable for the economical handling of the sand and aggregate that it will furnish and of the concrete into which they will go. All the rock will be taken from above a roadway which has been cut in the slope at an elevation 240 feet higher than the river. It will be loaded into trucks by power shovels, hauled a short distance to the primary crusher, conveyed across the intervening draw to a secondary crusher, and then moved on around the hill to the screening towers and the concrete mixing plant. This latter structure is located a few hundred feet from the runway for the cableway head towers. The mixed concrete will be dumped into transfer cars and hauled by gasoline-driven locomotives around the brow of the hill into position beneath the cableways. There the concrete will be poured from the car hoppers into 6-cubic-yard buckets which are not detached from the cableways.

In order to make certain that the rock was suitable for the intended purpose, several tons of it was sent to the Denver office of the Bureau of Reclamation, where it was subjected to extensive tests to determine the characteristics of the concrete which it would produce. These investigations showed that it was very satisfactory—in fact, the sand that will be derived from it is excellently adapted to the making of a strong concrete. Once this information was received, plans were made to sluice the overburden from the deposit, and this operation has been in progress for a number of months. Recently the work of blasting was started.



ARTIST'S CONCEPTION OF COMPLETED DAM

Norris Dam will back up the Clinch River 79 miles and its tributary, the Powell River, 45 miles. It will impound 3,600,000 acre-feet of water, a normal year's flow of the Clinch. Of this storage capacity, 1,600,000 acre-feet will be reserved for flood control. Through the 332-foot spillway and the power penstocks it will have a maximum discharge capacity of 253,000 second-feet. The two 66,000-hp. turbines in its power plant will operate under a minimum head of 160 feet and a maximum head of 213 feet, the average being 180 to 190 feet. The roadway which will cross the crest of the dam will be part of the Freeway.

The primary crusher is an Allis-Chalmers 42-inch gyratory type operated by a 250-hp. motor. Its product is delivered by a 36-inch rubber belt conveyor of 300-tons-an-hour capacity to a 2-deck, 6-inch and 3-inch screening tower. Following this comes the secondary crusher, a Symons cone unit driven by a 200-hp. motor. Next in line are four screening towers in which the aggregates are classified into four sizes ranging in diameter from ¾ inch to 6 inches.

Sand is made in two 42x48-inch Allis-Chalmers hammermills each driven by a 250-hp. motor. Hammermills were selected because of the various types of equipment designed for the purpose they were found to produce sand that will give the most workable concrete. Regarding this subject, Barton M. Jones, chief engineer, says: "This is primarily owing to the cubical shape of the grains. The cost of maintenance will be higher than for some other types of equipment, but the better sand will make possible an appreciable saving in the amount of cement required. This will materially reduce the cost of the concrete and give the advantages of lower

CONSTRUCTION STAFF

From left to right—Lex Phifer, general excavation and quarry foreman; J. B. Davis, chief storekeeper; George Naill, general foreman of core drilling and grouting; W. A. Jones, master mechanic; Dr. R. B. Watson, resident physician; O. A. Nystrom, chief clerk; P. M. Bedette, general carpenter foreman; E. C. McClenagan, general electrical foreman; Ben T. Clark, general rigger foreman; E. M. Whipple, assistant superintendent; Ross White, construction superintendent; F. C. Schlemmer, assistant superintendent.

FOR PLACING CONCRETE

Approximately 1,000,000 cubic yards of concrete will be required. It will be deposited in the forms, 6 cubic yards at a time, by two aerial cableways. These are the 110-foot tail towers on their runway above the east abutment. They are counterweighted at the back with precast concrete blocks to resist the forward pull present when they are carrying capacity loads of 16 tons.

temperatures by lessening the quantity of heat generated in the concrete". The sand is classified into two sizes, the finest of which is washed in a wet classifier for the removal of undersize material. All these products are piled separately over a concrete tunnel into which they can be drawn as required through gates. A belt conveyor within the tunnel moves them forward to an inclined conveyor which delivers them to the mixing plant.

The mixing plant is equipped with three 3-yard Smith tilting mixers each driven by a 40-hp. motor. Modern batching machinery weighs accurately the constituents which enter into each charge of the mixers. Bins over the mixing plant provide storage for small quantities of sand, aggregates, and cement. A cement silo of 6,000 barrels capacity has been built on the hillside 100 feet above the mixing plant. Bulk cement arriving in box cars at the railroad siding at Coal Creek is transferred by pneumatic pumps to a silo from which are loaded 65-barrel tank trucks which haul it to the dam site where it is unloaded pneumatically either into the storage silo or direct into the mixing-plant bins.

Concrete pouring was started on July 17, 1934. The main dam has been divided into blocks 56 feet long, and these are being built up in 5-foot lifts. The cableways transport the concrete to the forms in 6-cubic-yard, bottom-dump buckets. The schedule calls for placing the approximately 1,000,000 cubic yards in 21 months. The average monthly rate will be 44,000 cubic yards, and the maximum monthly rate 70,000 cubic yards.

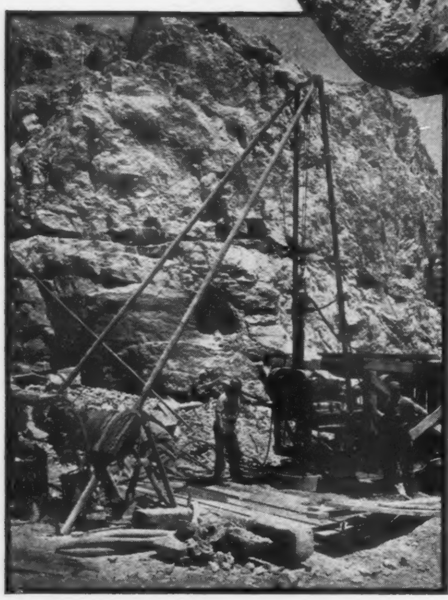
The original plans call for the building of a transmission line from the Muscle Shoals plant to supply power for the construction work. This line will not be completed for some time, but in the meantime Muscle Shoals power is being obtained over wires of the Tennessee Electric Power Company through an interchange agreement. That utility's 66,000-volt Coal Creek-Knoxville line passes within a quarter-mile of the dam site, and power taken from it is stepped down to 2,300 volts at a substation. When operations reach their height, the total connected load will be close to 5,000 hp. Motors exceeding 50 hp. use current of 2,300 volts. An 11,000-volt line was run from the substation to the new TVA Town of Norris, which is four miles distant, where many of the dam workers live.

To give employment to as many men as possible, work is carried on in four shifts of 5½ hours each for six days a week. This provides a 2-hour daily period for maintenance of equipment. Approximately 1,750 workmen are now engaged at the dam site, and it is expected that there will be 2,000 at the height of activities. Virtually all these men live in the Tennessee Valley. Many of them came from farms and were totally unfamiliar with construction operations of this nature. But they have proved to be speedy learners; and the average efficiency of the labor is fully as high as that found on similar undertakings elsewhere in the country. Wages range as high as $1.10 an hour for certain skilled workers. In order to transport the workmen between the dam site and the Town of Norris, the TVA maintains a free bus service.

The dam has attracted tremendous interest among residents of the region, and is also a show place for tourists. Although they are ordinarily not allowed to go down on the river bottom, there are ample vantage points from which the operations may be viewed. To show and explain the work to visitors, a corps of young men comprising what is known as the Guide and Guard Service is maintained by the TVA.

Norris Dam is being built under the direction of Barton M. Jones, chief engineer, and Charles H. Locher, construction consultant for this and the Wheeler Dam. Ross White is construction superintendent, and C. D. Riddle is construction engineer.

Safeguarding Norris Dam Foundations



TAKING 36-INCH CORES

By the use of the "Calyx" core drill (left), man is able to examine the rock on which the dam is to rest. At the rate of about 10 inches an hour the drill takes a cylindrical section, which is then broken off and removed from the hole in pieces that can be handled readily. Reassembled in the order of their extraction (above), these cores reveal the exact character of the foundation. Into the holes, themselves, geologists and others can descend to inspect the rock walls in place.

NEXT to safety, the foremost concern of dam builders is to make the barriers watertight. Being virtually impervious, concrete dams occasion little trouble from leakage through their own lines provided due care is taken to seal contraction joints. However, it is not sufficient to render the dam, itself, leakproof. Tremendous pressures are built up by the impounded water; and, unless the dam is underlain and flanked by solid rock, varying quantities of moisture will be forced through the formation under or around the concrete. This not only detracts from the usefulness of the dam but may, in some instances, weaken the structure and jeopardize its safety.

Engineers cannot, of course, choose the formations upon and in which to moor dams. They must accept the sort of rock that Nature provided, selecting the most suitable site within the area where other factors determine that the dam shall rise. Sometimes they are fortunate, as they were in Black Canyon on the Colorado River where the andesite breccia of the canyon walls and floor proved to be unusually sound and free from fractures. In other cases there are numerous flaws in the earth's crust, and suitable measures must be taken to close them so as to minimize or eliminate seepage through them.

The Tennessee Valley is not a paradise for the dam builder. Geological conditions are such as to create numerous problems which must be surmounted. Most of the stream channels are carved in limestone, a rock which, having been formed on the ocean floor, consists of beds or strata of varying thicknesses separated by stratification planes. In this region the beds lie almost flat, and, where fractures exist, water finds its way downward and flows along the subterranean divisions between the strata. Sometimes the layers of limestone are separated by thin seams of clay; other times the bedding planes are zones of more or less broken-up rock. Unless extreme care is taken to locate a dam in the most favorable area, and precautions are also exercised to seal the pervious portions of the underlying and adjoining rock masses, considerable water will be permitted to by-pass the artificial barrier.

A condition of this kind developed at the Hales Bar Dam, below Chattanooga, which was erected in 1913 by the Tennessee Electric Power Company at a cost of $11,000,000. Great quantities of water were found to be penetrating the rock in the reservoir area until it reached one of

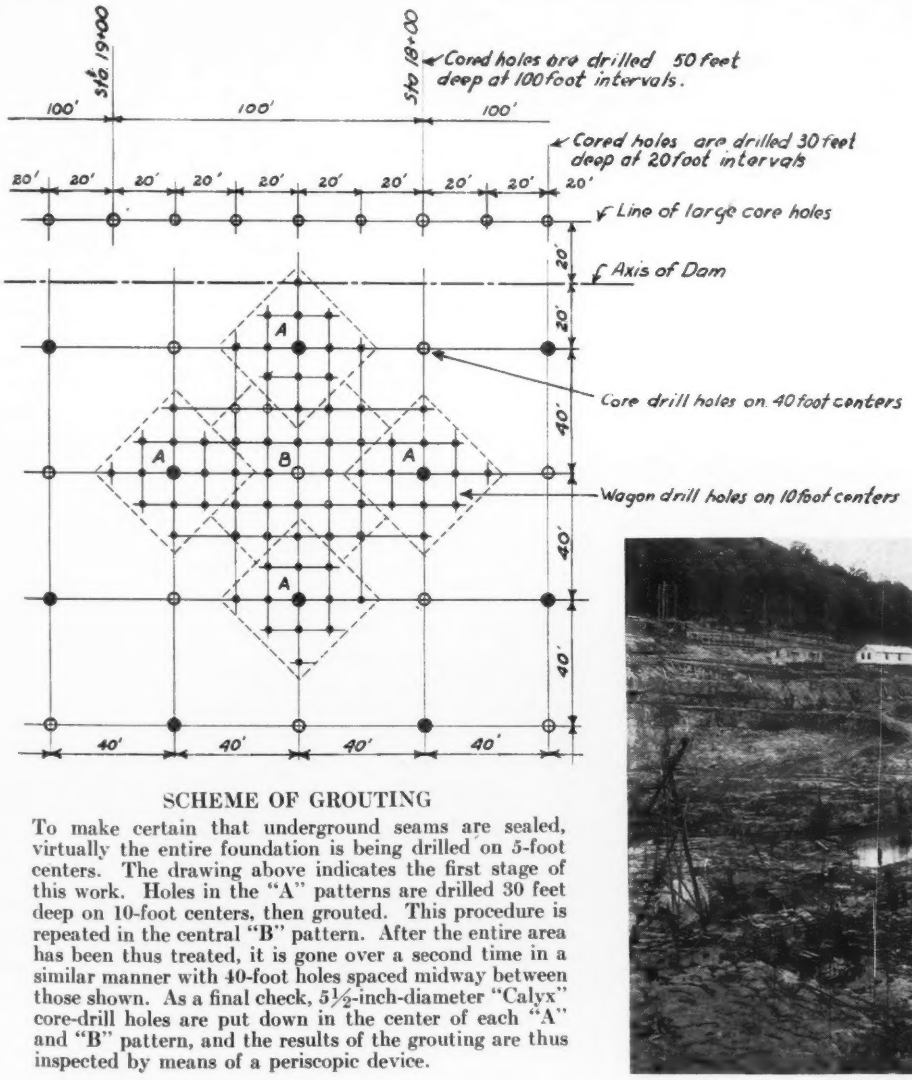
these division zones and then flowed underneath the dam. The safety of the dam was not immediately endangered, but the result was a big economic loss because the water escaped without performing its intended function of generating electricity. The trouble was eventually corrected at considerable cost by impregnating the subsurface areas in the vicinity of the dam with asphalt.

Because of the difficulties which the physical conditions imposed upon them, the engineers who investigated the site of Norris Dam took painstaking care to determine, in so far as possible, the character of the rock available for foundations and abutments. Under the direction of Maj. Gen. Harold C. Fiske, the Engineer Corps of the War Department, in 1923-24, spent $180,000 for researches at the dam site and within the reservoir area. While detailed topographic surveys were run for the purposes of relocating highways and for determining the reservoir boundaries, a considerable portion of this money went for exploring the subsurface at the prospective location of the dam. Extensive diamond-drilling was done to find out just what was underneath. These investigations were supplemented by others as the time for actual construction approached. Even the new science of geophysics was drawn upon to secure the desired information—International Geophysics having been commissioned to conduct a survey by the potentiometer and resistivity methods in order to ascertain the density and leakproof qualities of the ground. Dr. Charles P. Berkey of Columbia University, internationally known for his work as a consulting geologist on construction work, was retained as an advisor and has made a number of trips to the site to study conditions at first hand. Another recognized geologist, Dr. Arthur Keith of the University of Tennessee, made an investigation of the reservoir rock and reported upon its capacity to retain the water which was to be stored in the basin.

As was mentioned in a previous article, the rock which will inclose Norris Dam is a dolomite. It is, of itself, dense and compact, but occurs in beds of varying thickness that have interposed between them seams of clay, zones of broken material, and an occasional horizon which represents a mixture of dolomite, clay, and sandstone. Opening into some of these softer strata and located here and there in cliffs in the region are caves of irregular form, and their presence in exposed areas may be taken as an indication that percolating waters have perhaps formed similar openings in the deeper, hidden sections.

The remedy conventionally employed to consolidate and render impervious the rock underlying and abutting dams is that of introducing grout, the extent of this treatment varying with the character of the formation. Because of the numerous avenues for escape of impounded water that exist in this instance, unusual care is being taken at Norris Dam to secure definite advance information of underground conditions to insure a thorough grouting job. As grouting progresses, its effectiveness is being continually confirmed by the operations themselves and by a detailed study of the areas concerned. The procedure that has been developed for doing these things is unique in several respects and involves the use of certain equipment for the first time on this sort of work.

In order to check the preliminary test borings, a number of 36-inch-diameter holes was drilled at various points throughout the dam area to permit close inspection of the rock on which the structure will rest. These holes penetrated as deep as 52 feet, and enabled Doctor Berkey and all members of the consulting board to be lowered into them to examine closely and directly every inch of the walls throughout their depth. Some of the borings were made at points which had been excavated to grade, thereby permitting accurate first-hand determination of the character of the immediate foundation of the dam as well as of the ground a considerable distance beneath it. The cores extracted from the holes provided additional opportunity for studying the formation, thereby supple-



SCHEME OF GROUTING

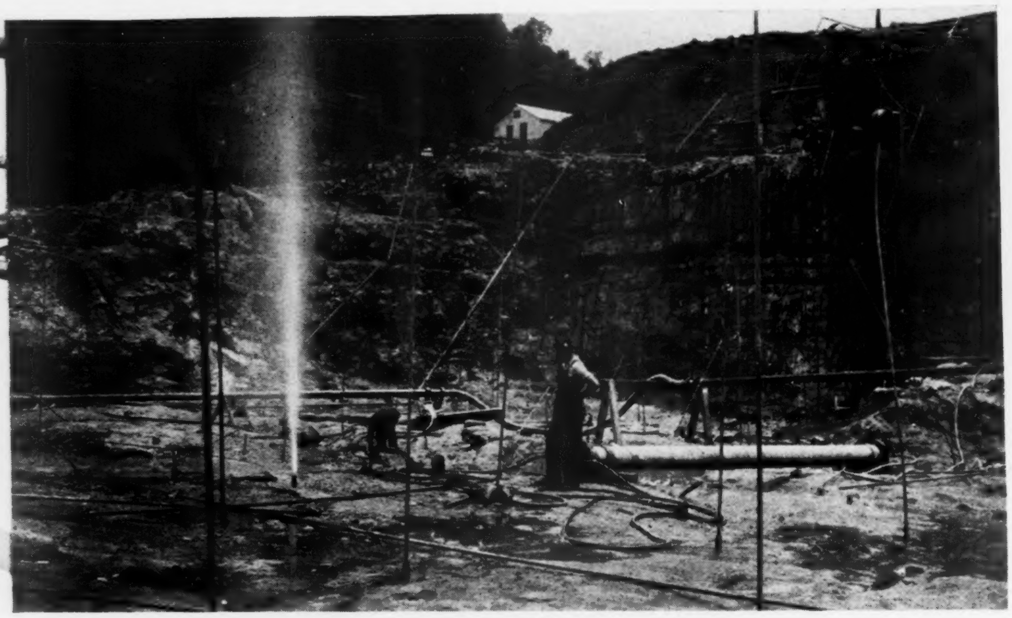
To make certain that underground seams are sealed, virtually the entire foundation is being drilled on 5-foot centers. The drawing above indicates the first stage of this work. Holes in the "A" patterns are drilled 30 feet deep on 10-foot centers, then grouted. This procedure is repeated in the central "B" pattern. After the entire area has been thus treated, it is gone over a second time in a similar manner with 40-foot holes spaced midway between those shown. As a final check, 5½-inch-diameter "Calyx" core-drill holes are put down in the center of each "A" and "B" pattern, and the results of the grouting are thus inspected by means of a periscopic device.

GROUTING OPERATIONS

The spillway-apron section of the foundation (below) with two grouting outfits at the left. Holes are being drilled, washed, and grouted. The rods sticking up are steel dowels which will reinforce the concrete.

WASHING AND GROUTING

A mixture of water and compressed air, which latter provides the required pressure, is directed alternately into two holes and forced back and forth in the underground seam, thus washing it clean. The water and air may be seen spouting from a hole (below). After an area has been washed, it is grouted through the same system of wagon-drill holes. Grout is applied at pressures not exceeding 30 pounds.

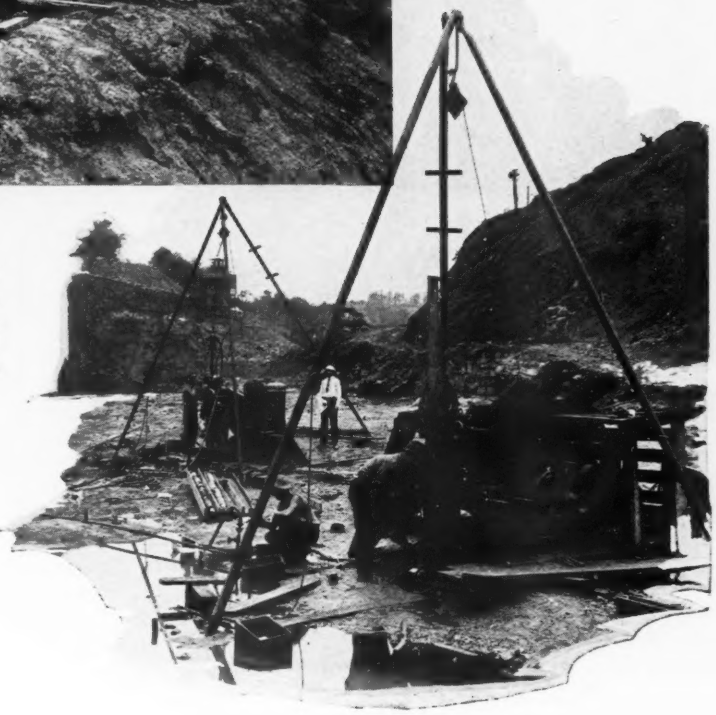


menting the observations made underground. So far as is known, this is the first time that drilled openings large enough for a man to enter have been systematically made in a dam foundation, although something of the same sort was done on a limited scale at Prettyboy Dam, near Baltimore, several years ago. The success which has attended its use may lead to the general adoption of the method for checking the results of earlier core-drilling wherever foundation material is of such a nature as to require careful procedure. Compared with the investment in the average large-size dam, the cost of such verification work is insignificant. A noteworthy advantage of the drilled exploration hole over shafts, or other excavations in which explosives are used, is that the rock can be seen in its natural unbroken and undisturbed condition.

The equipment used for drilling these 36-inch-diameter holes is an Ingersoll-Rand Class WS "Calyx" core drill. The bit is a section of ⅝-inch steel pipe having angular slots at six points equispaced around its cutting edge. The drilling medium is calyxite, or chilled steel shot, which is fed to the bit through the drill rods and carried under the cutting edge where it is pulverized by the rotating bit into sharp abrasive. Power for rotating the bit is supplied by a 15-hp. electric motor. The drilling equipment is mounted on a structural-steel frame and includes a Size HU air-driven hoist for removing cores and for handling other loads in and out of the hole. The core barrel is 4 feet long, permitting the taking of core sections up to that length. Core sections are broken off by placing a small charge of dynamite at any point at the bottom of the circular slot and by driving a wedge into the top of the slot directly over the explosive to exert assisting force. Detonation of the charge serves to break the core off at the bottom. A small shallow hole is then drilled with a "Jackhamer" in the center of the top of the core in which to insert a wedge pin for the removal of the core by the hoist. The speed of drilling with such equipment varies according to the character of the rock. At Norris Dam it is averaging about 10 inches an hour. Only two men are required to operate the drill. It is possible to reach depths of 200 feet with a drill of the aforementioned diameter.

Preliminary explorations disclosed that the rock was quite uniform and firm for a considerable depth below the level to which it was proposed to carry the excavation, but that farther down there was a seam of clay which required attention. Although the depth of the latter varied because of the differences in the amount of material removed in certain sections of the site, it lay 27 feet below the excavated surface of a large part of the area. It was desirable to know the persistence and general trend of this seam and of other lesser breaks in the dolomite, and this knowledge was secured in an ingenious manner. On lines 100 feet apart and running in both north-south and east-west directions, wagon-drill holes were drilled 30 feet deep at 10-foot intervals. Into each of these holes there was inserted a mechanical "feeler" which was developed on the job. As illustrated, this consists of a 1-inch pipe having inside of it a ½-inch rod for the manipulation of two arms extending out from the lower end of the pipe on opposite sides. These arms fit into recesses in the outer pipe while it is being lowered into a hole. The operator then pushes downward on the rod, causing the arms to flare out until their tips come in contact with the side walls. By carefully drawing the pipe upward with its arms extended, it is possible to locate seams and breaks and even to distinguish between small and large ones. By utilizing the mechanical feeler, the engineers traced the major clay seam throughout the entire area that had been drilled. Knowing the elevation at the top of each hole, they were enabled, by simple measurement, to determine its depth from that point, and it was then a simple matter to prepare a profile map showing the exact disposition of the seam with respect to the surface. This investigation gave information not only as to the persistence of the zone but also revealed variations in its thickness. These facts proved very helpful in determining how much grouting would be required and what procedure should be followed to assure successful treatment.

The system of applying grout was worked out especially to meet the existing conditions, and is distinctive with this job so far as those in charge of it know. It was desirable, if the grout were effectually to develop the full supporting power of the rock and to seal off the watercourse, that



SMALL CORE DRILLS AND CORES

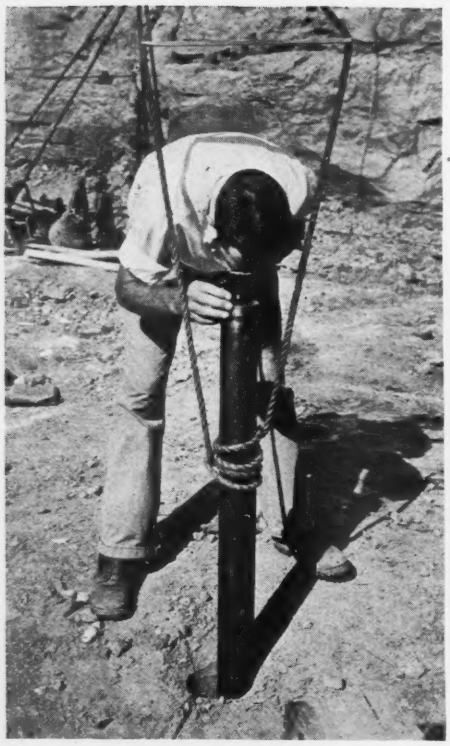
Six 5½-inch core drills are in service. In addition to their use in connection with grouting, they are also employed for deep exploration work. The two machines shown at the right are drilling 100-foot holes in the floor of the uppermost of the series of ledges on which the east end of the dam will rest. The extracted cores are preserved in racks (above) and constitute records of the foundation at various points.

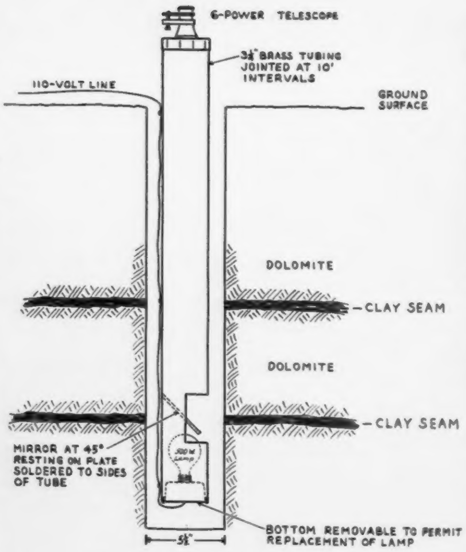
the clay and other fine material should first be removed from the seam. This is done by washing it out with water and air combined—the air providing the necessary pressure—and by using the same holes that are later employed for grouting.

The layout scheme of these holes is shown in an accompanying sketch. The principle of the plan is to treat sections of the entire grouting area as individual units, and then progressively to extend the work until all parts have been covered. Within each localized section the procedure is to consolidate the outer areas first and then the center. Reference to the drawing will aid in understanding how this is done. Thirty-foot wagon-drill holes are put down on 10-foot centers in the four square areas designated "A". There are thirteen holes in each square, or 52 in the four. Washing and grouting operations are next carried on in each of these areas. After the "A" groups have been thus treated one at a time, the holes in the central area designated "B" are drilled, washed, and grouted. Similar interconnecting "A" and "B" patterns are then treated until the whole foundation area has been grouted, after which the entire procedure is duplicated by going over first the "A" patterns and then the "B" patterns with 40-foot holes spaced between those previously drilled. The eventual layout is, therefore, one of holes on 5-foot centers, half of which are 30 feet deep and half 40 feet. It will be noted that in the middle of each "A" and "B" group—that is, at the 40-foot centers, larger holes are indicated. These are "Calyx" drill holes, 5½ inches in diameter. They are drilled for further inspection of the foundation rock and as an aid in washing, as will be explained presently.

As previously noted, the drilling of a group of holes is followed by the washing operation. This is done by making connections between two holes and hoses extending from a pipe-section receiver containing compressed air at not more than 30 pounds pressure. A valve at the outlet permits changing the air pressure from one hole to the other; and, by suitably manipulating it, the water mixed with air can, accordingly, be forced back and forth in the underground seam. At times, enough water is present in the particular section being washed to supply the needed water; but when more is required it is furnished from above. One or more drill holes in the area under treatment are left open as outlets for the air and water, the others being closed by capping the inserted 1½-inch pipe nipples. The air connections are periodically changed from hole to hole until air has been introduced into all of them, and the water discharge is likewise shifted among the holes. The process is continued until the water coming from the ground is entirely clear, indicating that the flushing action has removed all the clay and other fine material from the seam within the zone being treated.

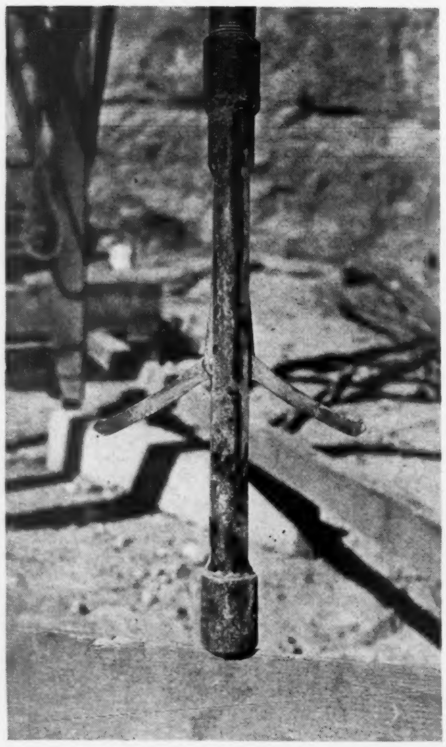
The area is then ready for grouting, which is done in the conventional manner. Two similar grouting units are employed, each consisting of a piston-type pump and a 2-compartment mixer equipped with a close-quarter air drill for turning the mixing paddles. The grout is pumped through a hose to a hole, where a nipple connection is made with a 1½-inch pipe extending about a foot into the ground. The grout, a mixture of neat cement and water, is applied at not more than 30 pounds pressure. Depending upon underground conditions,





LOOKING UNDERGROUND

The drawing indicates how the engineers examine the results of the grouting. With a mechanical "feeler" (right) they locate seams. Grouted areas are inspected by lowering a periscope into the core-drill holes by means of tackle suspended from a timber A-frame.



the holes each take from one bag of cement up to as many as 200.

The checking operations, in which the 5½-inch holes play a part, constitute one of the most interesting phases of the entire work. By means of these openings, and with the aid of a periscopic instrument designed for the purpose, the engineers are enabled actually to look underground and to inspect the quality of the grouting that has been done.

As can be noted on an accompanying sketch, the periscope utilizes a 3¼-inch brass tube. This is made up in 10-foot sections and fitted with joints that permit varying its length from 10 to 30 feet. A cap that fits over the top has a 6-power telescope built upon it. Near the bottom of the tubing, resting on a plate that is soldered to its wall, is a mirror set at an angle of 45°. Beneath it, mounted on a removable base which provides for its easy replacement, is a 500-watt electric lamp which receives its current from a 110-volt line run down the hole at the side of the tubing. Opposite the mirror, a section of the tubing is cut away to permit the observer to view the rock wall of the hole. Below the mirror the interior of the tubing is coated with aluminum paint to give it maximum reflective power. Above the mirror the tube interior is painted a dull black to reduce reflection.

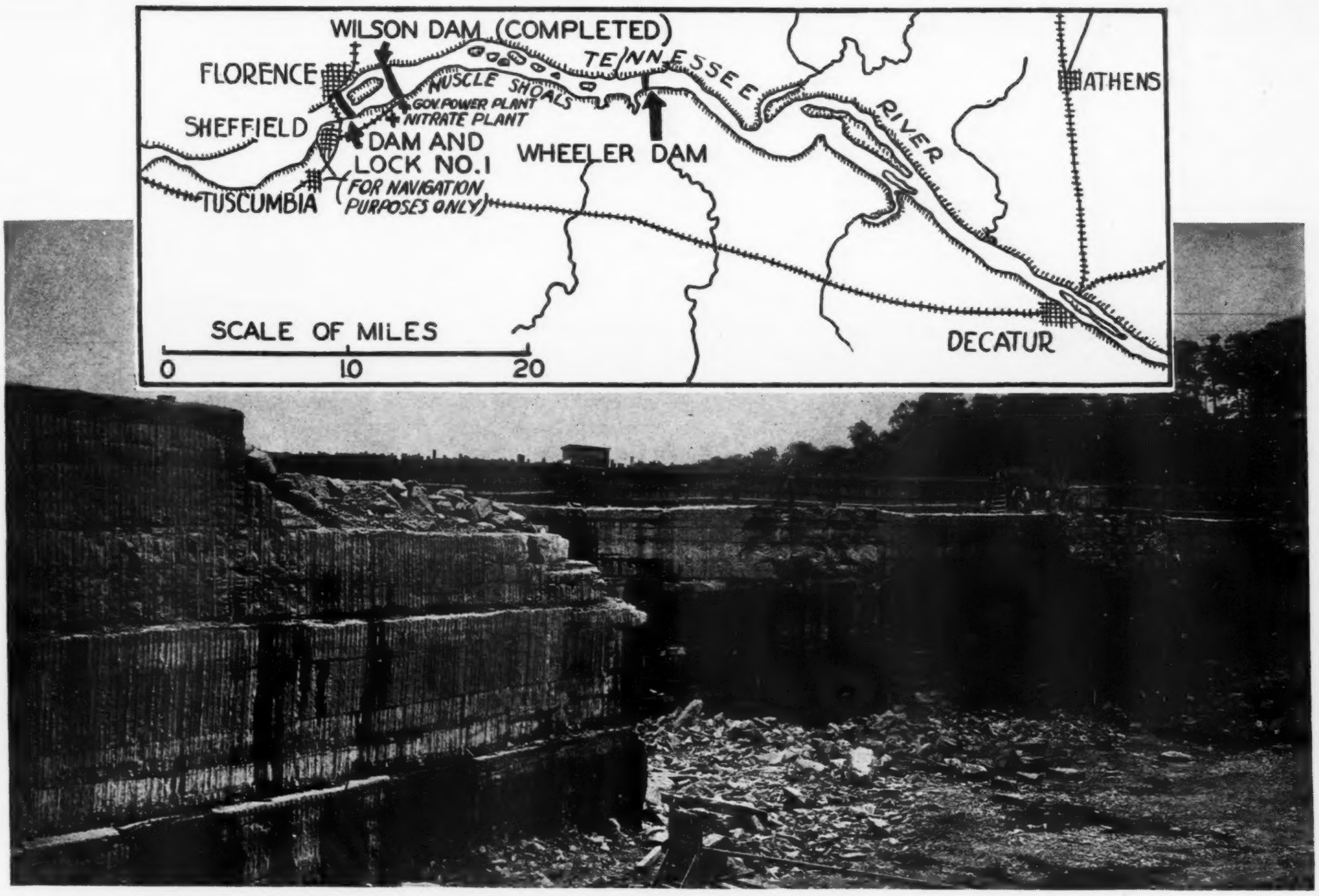
The periscope is suspended by ropes from a timber A-frame a little more than 30 feet high. It is lowered with this tackle for observation. It can be freely revolved with the hands until the operator has had an opportunity to examine the full circumference of the wall at any point being studied. The concentration of a strong light just below the mirror serves brilliantly to illuminate the side of the hole—the visibility being virtually equal to that of strong sunlight. The core that is taken from the hole furnishes, in each instance, corroborative evidence of the periscope's disclosures. Together they give absolute proof of just how thoroughly the grout has filled the underground openings and eliminate the element of chance and guesswork. If the grout has not reacted satisfactorily, further grouting is done.

As can be readily comprehended, this painstaking procedure calls for the drilling of a large number of holes. As the work progresses, changing conditions may call for modifications of the spacing arrangement, but the engineers estimate that the total will be somewhere between 8,000 and 12,000 holes. Although most of them will be of small diameter, something over 500 will be of the cored type. The "Calyx" drill rigs which are used for the latter holes are similar to the large one already described, save for the difference in size. They are designated as K-3 machines, and there are six of them in service. Having less material to cut, they operate faster than the 36-inch unit and are maintaining a rate of more than a foot of hole an hour.

These same drills assisted materially in revealing the character of the subsurface where the easterly base of the dam will rest on a series of stepped ledges at progressively greater height above the river level. A number of holes 100 feet deep was drilled along the axis of the dam for purposes of exploration and grouting. The core sections from these and other purely exploratory holes were numbered as they came from the ground and then preserved in cases especially made for them, thereby providing a record of the formation at each point tested.

Still another precaution was taken to probe uncertain horizons at the dam site. Excavations for the eastern part of the dam revealed a seam of soft material at a level about 50 feet above the river. A series of drifts about 4x5-feet in cross section and parallel to the axis of the dam was driven horizontally at different points along this exposure and, of course, within the dam lines. According to what was divulged by them, these drifts were advanced varying distances—the upstream and deepest one extending 260 feet in from the face. Each adit was driven with an Ingersoll-Rand wet "Jackhamer" of the S-49 type mounted on a column and arm. The normal drilling round consisted of twelve holes; and to prevent serious damage to the formation the average advance per round was limited to about 3 feet. The muck was wheeled out in barrows and dumped over the cliff for loading into trucks by power shovels. The openings thus made were used to introduce concrete along the entire length and width of the seam which they followed. In addition to the shallow grouting operations that have been described, grouting at deeper levels in the foundation and under somewhat higher pressures will be done later on in the course of the construction work.

In view of the almost meticulous care that is being taken to seal the hidden water channels in the abutments and foundations, it appears conservative to predict that Norris Dam will prove thoroughly tight for many years to come despite the porosity with which Nature has endowed the formation which will inclose it.



FIFTY MILES OF DRILL HOLES

The back wall of the power-house area, where the excavation reaches 51 feet below the river bed. The indentations are for the installation of generating units. All of this wall was line drilled, involving about 262,000 linear feet of holes. At the time this picture was taken about 10 feet remained to be excavated from the bottom. At the top is a general location map of Wheeler Dam and vicinity.

Wheeler Dam

WHEELER Dam is named for the illustrious southern soldier General Joe Wheeler, who led forces in both the Civil and Spanish-American wars and who made his home at Wheeler, Ala., not far from the dam site. It will span the Tennessee River at the upper end of Wilson Lake, and its length of 6,336 feet will place it among the longest structures of its kind in the world. Exclusive of power-house equipment and navigation lock, it will cost about $20,000,000. It is scheduled to be completed in two years.

In purpose, character, and construction methods, it differs materially from Norris Dam. It is a run-of-the-river dam, designed primarily for power generation and navigation improvement, whereas Norris Dam is intended chiefly for storage. It is a low dam, while Norris is a high one. Differences in the dams, themselves, and in their settings call for the use of different tactics in their building. Norris Dam site, being in a comparatively wild and isolated section, had to be made accessible by roads before work could start. Wheeler Dam, on the other hand, is receiving construction equipment by water. With high banks on either side, cableways are the natural solution for handling concrete at Norris Dam. The relatively low banks at Wheeler dam site and the great length of the structure make cableways unfitted for service, but the existence of navigable water renders it possible to use floating concrete-mixing equipment to advantage.

A power house is being provided for at Wheeler Dam and will eventually be operated; but for the time being only one generator will be installed and the dam's contribution to the generation of electricity will, in part, be in the form of increasing the capacity of the Muscle Shoals plant just below it. Although the installed capacity at Muscle Shoals is 261,000 hp., the river flow is so irregular that during the dry season the normal actual capacity is around 100,000 hp., and in 1925 it dropped to less than 55,000 hp. By contrast, and were it possible during times of flood to convert all the available energy of the falling water into electricity, it is estimated that the plant could produce 2,000,000 hp.

As has been explained in foregoing articles, one of the prime purposes of the dam-building program is to regulate the river flow so that extreme variations will no longer occur. Although, as noted, Wheeler Dam's chief function is not that of storing water, its storage capacity will, nevertheless, have the effect of increasing the firm or continuous capacity of the Muscle Shoals plant by about 27,000 hp. With both Norris Dam and Wheeler Dam in commission, it is expected that the flow of the river can be maintained so that the available capacity at Muscle Shoals will never fall below 300,000 hp. This latter condition obviously assumes that the generating facilities of the plant will be increased, which is in accordance with the original plans. The ultimate river-development scheme of the TVA contemplates giving Muscle Shoals a dependable output of approximately 600,000 hp. In its own right, Wheeler Dam will have an ultimate generating capacity of 450,000 hp., consisting of ten 45,000-hp. units. The present

plan, as already mentioned, is to install one 45,000-hp. unit and the others when and as the demand for power increases susfficiently to require them.

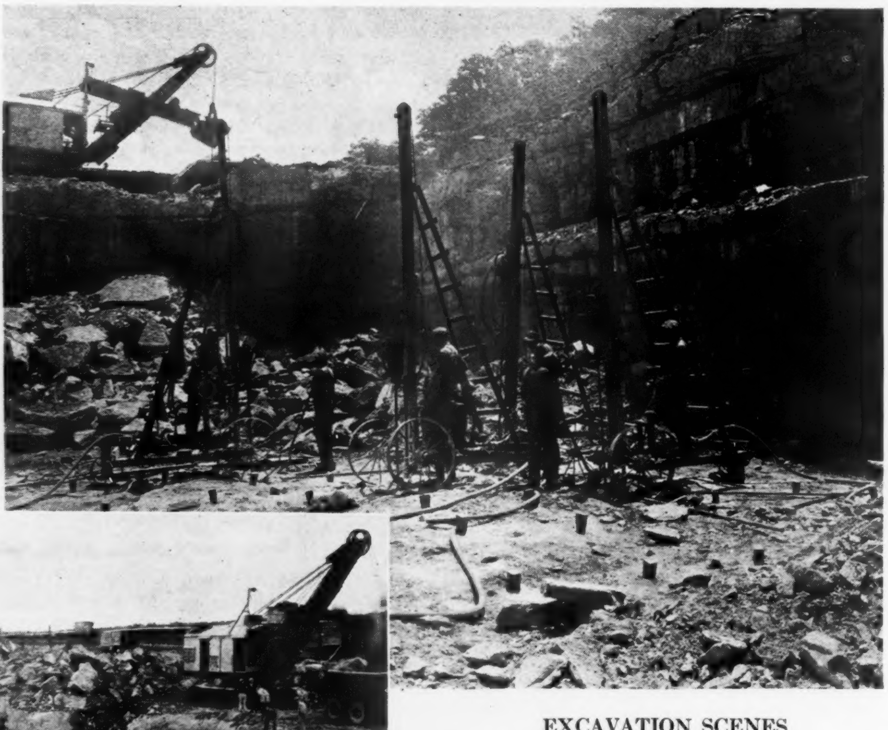
Wheeler Dam will be a gravity-type, concrete structure generally similar to Wilson Dam. It will raise the river level 50 feet, creating a lake 89 miles long, 9 miles in maximum width, and covering an area of about 100 square miles. It will have a normal basal width of 54 feet, and the 20-foot roadway which will cross its crest will be 70 feet above the foundation. It will contain approximately 600,000 cubic yards of concrete. The power house, about 805 feet long and 170 feet wide, will be at the south end. Next to the power house will be a trashway, and adjoining it will be 480 feet of nonoverflow section. Next will be 2,700 feet of spillway, consisting of 60 sections each 45 feet wide and fitted with a radial-type gate. North of the spillway will be 1,637 feet of nonoverflow section, a trashway, a navigation lock, and, finally, 236 feet of nonoverflow section. The lock, which is nearing completion under a private contract, is described in the next article. To avoid interference with traffic across the dam when the lock is in use, the surmounting roadway will be elevated at either side of it and will cross the lock section by means of a bridge having 57 feet of clearance above extreme high water. The total length of the ramps and bridge will be 1,650 feet.

In October, 1933, President Roosevelt requested the TVA to begin the construction of this project. Work was underway on November 20, following. It was possible to obtain this rapid start for several reasons. In the first place, all the required preliminary engineering data had been assembled at the time Wilson Dam was built. From them, the Denver office of the Bureau of Reclamation, working under the direction of Chief Designing Engineer John L. Savage, speedily prepared plans. Secondly, the site was immediately accessible from the waters of Lake Wilson, making it unnecessary to construct railroads or highways for the purpose of moving in equipment, materials, and supplies.

As is the case with Norris Dam, an important accessory activity is the acquisition of the land which will be covered with water. Although the area is greater, Wheeler Dam does not present the problems that Norris Dam presents, there being only about 800 tracts to secure and no towns nor cemeteries to contend with. To expedite the work, an aerial survey was made of the region and mosaic maps assembled to assist the legal and land-buying departments. About 50 per cent of the land is timbered. Approximately 3,000 men are now engaged in clearing the site. They work in units of 60 each, and a unit is divided into three groups. The first is the bush-hook crew, which cuts and piles the lighter growth. The ax men follow, and cut, trim, and pile the smaller trees. Then the sawyers, two men to a crosscut saw, fell the large trees, trim them, and cut them into logs of convenient length for handling. These logs are later assembled into piles, and are sawed into timber or burned, according to their worth and accessibility. Certain valuable woods, such as walnut, are made into lumber regardless of their location. This will be used largely for TVA construction purposes, and any surplus will be sold.

As work was already in progress on the lock near the north shoreand that area was, accordingly, congested, the engineers elected to begin operations on the south bank. Conditions called for unwatering working sites by means of cofferdams. Five of these will be required to carry the work progressively across the river. The first one reaches out into the river 1,400 feet on its upstream side, and has an outer wall running riverwise for 436 feet and a connecting downstream side extending 1,450 feet back to the river bank. The walls are 20 feet thick and 16 feet high, and consist of timber box-type cribs faced with sheathing and filled with gumbo dredged from a nearby island by the U. S. Engineers' dipper dredge *Virginia* and transported by barges. The building of the nearly 3,300 linear feet of this cofferdam and the unwatering of the area it incloses were completed on January 18, 1934, just seven weeks after the initial forms were placed.

The total estimated excavation for the dam is about 500,000 cubic yards. More than half of it—approximately 270,000 cubic yards—will come out of the first cofferdam, which includes the power-house area. The estimated quantities for the other cofferdams, in cubic yards, are: No. Two, 81,000; No. Three, 78,000; No. Four, 40,500; No. Five, 20,000. The second cofferdam, adjoining the first one on the north,



EXCAVATION SCENES

Within this first cofferdam of the five that will be required in extending the dam across the river will be excavated more than half of the total 500,000 cubic yards of rock that will have to be removed. Wagon drills carry the burden of the drilling work, and more than a dozen of them keep two huge electric shovels supplied with muck. The four X-71 drills shown above are putting down holes in the power-house area.

LOADED HOLES

Looking along the dam line, with the excavation for the south abutment visible in the bluff in the background. These holes were the first to be drilled in this area, and the surface shown represents the river bed as it was uncovered. It runs smooth and even like this all the way across its width of more than a mile. The holes were put down with wagon drills, and are on about 5-foot centers.

FLOATING CONCRETE MIXERS

Two of the four barges on which concrete will be mixed outside of the cofferdams. The cranes will deliver aggregates to the bins and will also transfer mixed concrete in 2-cubic-yard buckets to points of pouring. Inside the first cofferdam area will be stationed six traveling hoists with 95-foot booms that will carry the concrete to the power-house forms. These barges were assembled at Muscle Shoals and towed across Lake Wilson.

has already been constructed and work will soon be extended to it. It is 1,215 feet long, 226 feet wide, and consists of rock-fill walls blanketed with clay and sheathed with light boards to prevent washing.

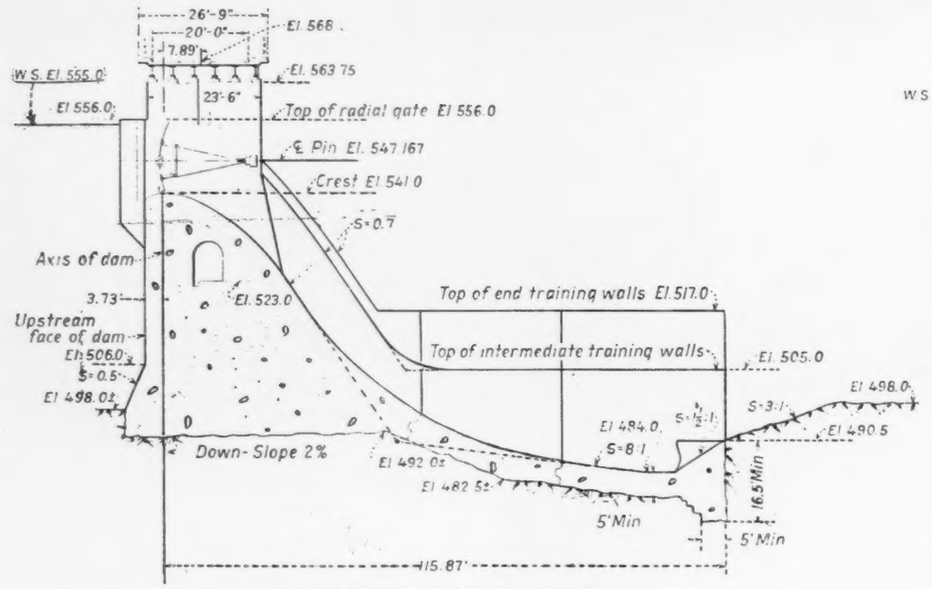
Preliminary data had disclosed that rock occurs virtually at the river bottom and that it runs remarkably level clear across the wide stream, being found at elevation 498 which is 7 feet below the surface of Lake Wilson. The rock is a dense limestone of blue color. It lies in horizontal beds which are generally thicker and less fractured than those at the Norris dam site. Stratification planes are usually quite free from clay and do not exhibit much broken rock. Drilling in the first cofferdam revealed some narrow bands of flint. The only requirement for the foundation is that the dam shall rest on a firm stratum at least 4 feet thick. To make certain that this specification will be fulfilled, three 5½-inch core-drill outfits work ahead of the excavation crews, extracting sections for examination at intervals of 20 feet.

The general plan of excavation calls for taking out 6 feet below the rock line in the areas where the dam will rest, except in the intake directly behind the power house where 13 feet is being removed. In the spillway section, an apron will extend about 116 feet downstream from the axis of the dam. This structure will have a slope of 8 to 1, terminating in a keyway 5 feet in minimum cross section and having a minimum thickness of 16½ feet. The low point of the keyway will be 24 feet below the river-bed rock. Foundations for the power house are being excavated to a maximum depth of 53 feet.

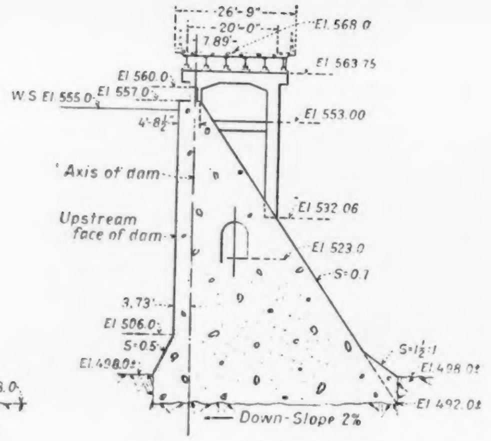
While the first cofferdam was being constructed much other preparatory work was underway. To provide power at the site, a 17-mile, 12,000-volt transmission line was run from the Muscle Shoals power plant in exactly two weeks. A substation was erected to transform the current into the several different voltages which are used. A compressor house, machine shop, warehouse, and other required service structures were built. Two electric-driven stationary compressors, having a combined piston displacement of 4,200 cfm., were installed. These units are Government-owned machines which were used during the construction of Wilson Dam. An office building for the engineering staff was built on the bluff above the river. Farther back, on higher ground, a cafeteria, dormitories, and other camp structures were erected. It is not expected that there will be any great need for housing workers, as most of the employees live nearby. However, accommodations are available for 1,000 men. A few hundred yards upstream from the camp has been established the nucleus of a modern, permanent town. Attractive residences have been constructed there on high ground overlooking the river, water and sewage systems have been laid, and landscaping is in progress. These homes are now occupied by members of the engineering and construction staffs.

To provide for the delivery of construction materials and equipment, a barge landing was built on Lake Wilson a short distance from the site. This was later improved by the addition of a pier and breakwaters, forming a harbor about 200x200 feet in size. The breakwaters, which are made up of timber cribs filled with rock from the dam foundation, are required because Lake Wilson becomes choppy during stormy weather. As excavating proceeded, the rock was used to build up a narrow, level stretch of land along the shore of the lake below the dam site. A sharpener shop, carpenter shop, warehouses and other structures necessary for the construction work have been erected there.

Two 2½-yard electric shovels designed for loading excavated materials were assembled at Muscle Shoals, loaded on barges, and towed across Lake Wilson to the dam site. Each weighed approximately 100 tons. The first one arrived before Cofferdam No. 1 was completed. It was run off the barge on to a rock-filled timber crib within the cofferdam area, and remained there until the water had been pumped out. The second shovel reached the scene of activities after the cofferdam was in place but before it had been un-



SECTION THROUGH SPILLWAY



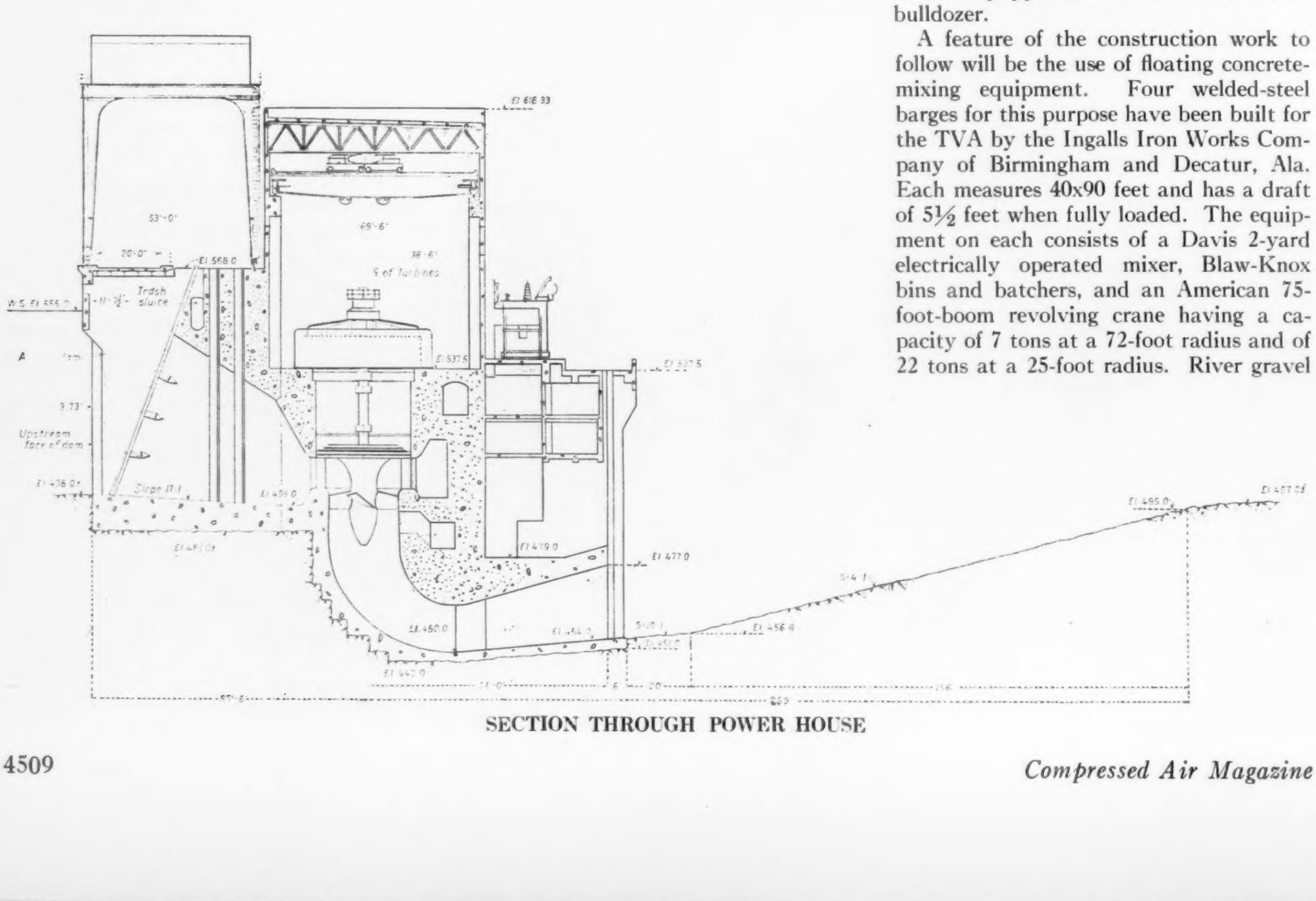
NONOVERFLOW SECTION

watered. It was unloaded on to a crib just outside the cofferdam and run across steel girders to a second crib inside the cofferdam.

To provide a haulageway into the cofferdam, a ramp was built at the downstream corner adjacent to the river bank. All these accessory structures and operations either had been completed or were well along by the time the cofferdam was ready for unwatering; and excavating was started even before the surface of the exposed river bed was dry. Wagon drills were selected for the bulk of the drilling, and a number of Ingersoll-Rand X-71 units began work in the power-house area. As illustrated in an accompanying photograph, the back wall of the section where the generating equipment will be placed was line drilled so that the rock might be broken to clean surfaces. As recesses were cut back into the wall at the respective sites of the eight future generating units, and as the area concerned was 610 feet long, this involved an extensive drilling program. Line-drilling was carried to a depth of about 50 feet and was done in four lifts. The maximum lift was 22 feet. The holes were drilled on 4¼-inch centers. A total of 262,000 linear feet of hole was required for this phase of the drilling program, exceeding all the drilling done for purposes of excavation during the first five months of operations on the cofferdam.

On the excavation work, wagon-drill holes are put down on 4- or 5-foot centers, loaded with 40 per cent Hercules dynamite, and fired electrically. As at Norris Dam, shooting is done at any time a group of holes is loaded, a warning signal being sounded by a compressed-air whistle. Loading of muck is done by the two power shovels previously mentioned. One is a Bucyrus-Erie 75-B and the other a Marion Type 4101. The rock breaks in larger pieces than that at Norris Dam, requiring some secondary drilling with "Jackhamers." Hauling is done by seven trucks —six Whites and one Hug—equipped with 10-yard apron-type steel bodies. Some of the rock goes into cribs, cofferdams, etc., and the remainder is used in extending the made land alongside Lake Wilson. It is spread and leveled by a Caterpillar 70 tractor equipped with a LaPlante-Choate bulldozer.

A feature of the construction work to follow will be the use of floating concrete-mixing equipment. Four welded-steel barges for this purpose have been built for the TVA by the Ingalls Iron Works Company of Birmingham and Decatur, Ala. Each measures 40x90 feet and has a draft of 5½ feet when fully loaded. The equipment on each consists of a Davis 2-yard electrically operated mixer, Blaw-Knox bins and batchers, and an American 75-foot-boom revolving crane having a capacity of 7 tons at a 72-foot radius and of 22 tons at a 25-foot radius. River gravel



SECTION THROUGH POWER HOUSE

FIRST DRILLING

The wagon drills shown above were photographed on January 26, five days after the first cofferdam was unwatered.

DIRECTING THE WORK

Members of the construction and engineering staff, from left to right: First row—Lee H. Huntley, construction superintendent; George K. Leonard, assistant construction engineer, B. S. Philbricks, assistant construction superintendent; and W. M. Hall, construction engineer. Second row—W. S. Wooten, chief clerk; J. C. Gilbert, field engineer. Third row—T. R. Koonce, general carpenter foreman; W. C. Winters, general excavation foreman; J. P. Laws, office engineer; G. C. Dunnagan, general electrical foreman. Rear row—W. R. Johnson, concrete technician; C. E. Wattles, chief surveyor; J. W. Almquist, purchasing agent; D. H. Roby, master mechanic.

and sand will be purchased from the Cumberland Sand & Gravel Company, which will dredge the material below Sheffield, near Muscle Shoals, and transport it to the dam site by a fleet of 30 barges. It will be transferred into the mixing-plant bins as required by the revolving cranes. Bulk cement will be brought by rail from Birmingham to Sheffield, where it will be loaded by Fuller-Kenyon pneumatic pumps into floating equipment which will move it to the dam site. Other pneumatic pumps will there deliver it to the mixing-plant bins. The floating mixers will be stationed just outside the cofferdam area. Inside the cofferdam area six Clyde revolving hoists mounted on rails and having 95-foot booms will transfer all concrete from the mixer barges to the forms. Bottom-dump buckets with a capacity of 2 cubic yards will be used for pouring.

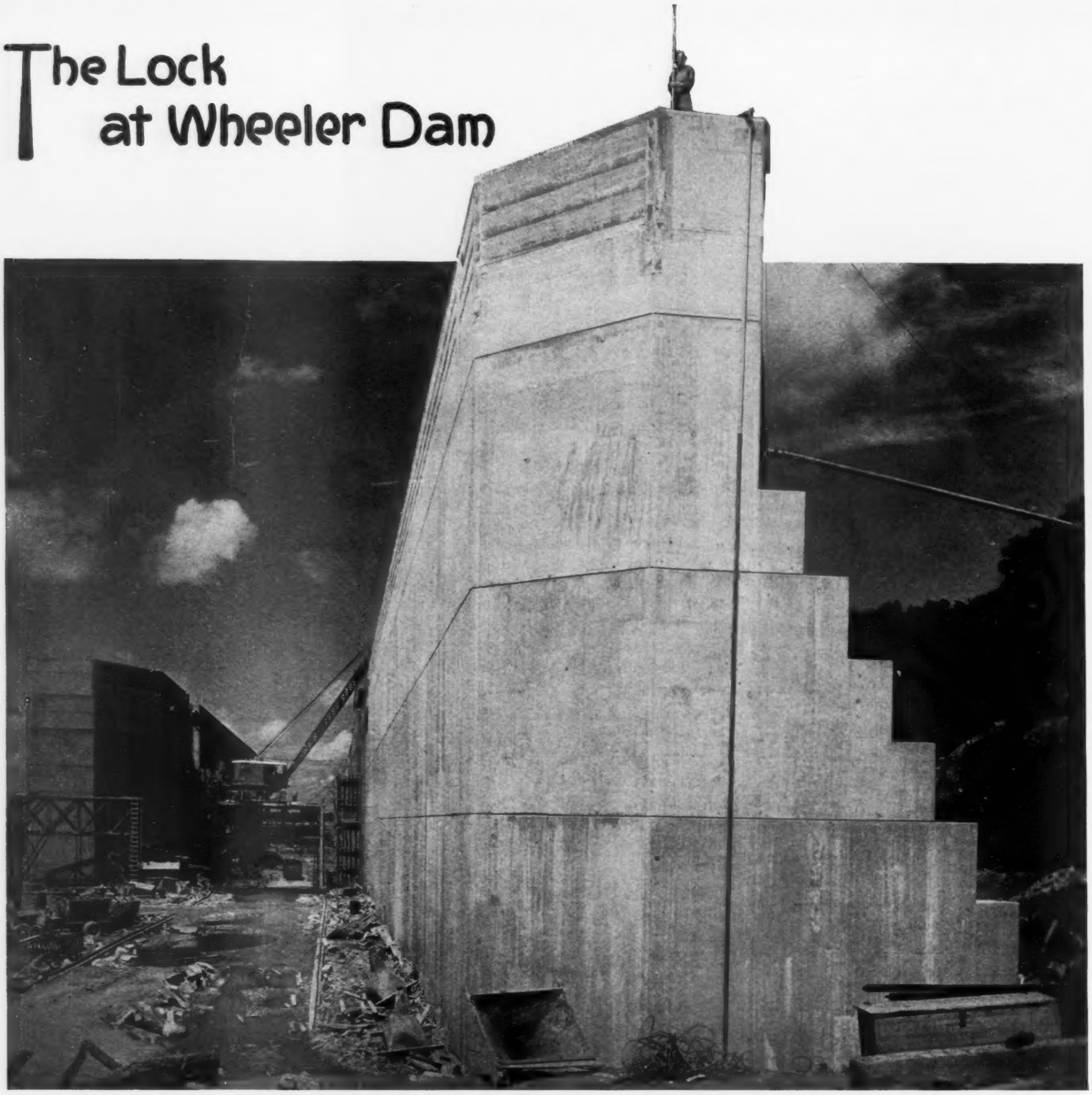
Work is being conducted 22 hours a day with four shifts working 5½ hours each. A shut-down of two hours is made for oiling and maintaining machinery. Illumination is provided at night by flood lamps stationed at various points on top of the cofferdam.

Save for the navigation lock, the work at Wheeler Dam is being done by Government forces. Lee H. Huntley is construction superintendent and W. M. Hall serves as chief construction engineer. C. H. Locher is consultant on construction engineering, and Dr. Charles P. Berkey is consulting geologist. An advisory board which meets periodically at the invitation of the TVA to review plans and progress consists of Frederick W. Scheidenhelm, hydraulic engineer of New York City; Leroy F. Harza, consulting engineer of Chicago; Sherman W. Woodward, of the University of Iowa; and Charles H. Paul, of Dayton, Ohio, consulting engineer and designer and builder of the Arrow Rock Dam for the Bureau of Reclamation. The same group of experts serves in a similar capacity in connection with the work at Norris Dam.

A HUNDRED-TON LOAD

Before the first cofferdam was completed, two electric shovels were assembled at Muscle Shoals and towed to the dam site, where they were unloaded on rock cribs pending the unwatering of the area where they were to work.

The Lock at Wheeler Dam



FOR FUTURE COMMERCE

Looking into the lock, with the upper end of the landward guide wall on the right. This structure will raise river craft 50 feet from Lake Wilson to the reservoir to be formed by Wheeler Dam. The wall in the foreground rises 76 feet from its footings. Note the smooth appearance of the concrete. It was obtained by lining the forms with "prestwood."

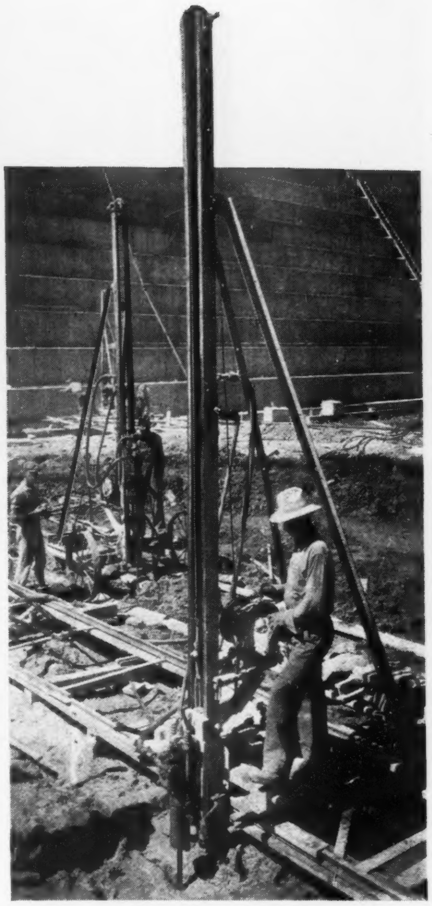
IMPROVEMENT of the navigational facilities of the Tennessee River, which is one of the chief objectives of the TVA movement, was first agitated more than 100 years ago. The Government's interest in the matter dates back to 1824, when John C. Calhoun, then Secretary of War, urged that a survey be made at Muscle Shoals, Ala., with a view to providing a waterway passage of those rapids. He advocated such a course on the grounds that navigation of the river was a military necessity. At the time the river was navigable for small craft from its mouth to that point. Acting upon Calhoun's suggestion, a survey was made and a canal was recommended. For the purpose of financing its construction, Congress, in 1828, allotted 400,000 acres of Government land in the Tennessee Valley to the State of Alabama. Upon being sold by the state this land brought $600,000.

Work was begun on the canal in 1831, and was completed five years later. From the beginning, however, the waterway was considered inadequate and was soon abandoned. Meanwhile, a railroad had been built around the shoals, running from Tuscumbia to Decatur, Ala. It was called the Tuscumbia, Courtland & Decatur Railroad, and was the first to be constructed in the Tennessee Valley. Freight coming up the river in barges was transferred by it around the impassable stretch to other barges above. Available records do not disclose whether the existence of this line was a factor in the abandonment of the canal.

Official recognition of the need for an adequate canal was next given, in 1871, by the Rivers and Harbors Act which carried a provision authorizing another survey. As a result of the investigation which followed, construction on a second canal was begun in 1875. It required fifteen years to complete the work,which cost $3,191,726. It is of interest to note that George W. Goethals, who later directed the building of the Panama Canal, worked on this Alabama project as a young captain of engineers. When Wilson Dam was constructed, the

BUILDING THE CONNECTING DAM SECTION

Space was left between the lock and the north shore to provide sufficient room for a larger lock should future traffic require it. Meanwhile, the gap will be filled with the same type of dam construction that is on the riverward side of the lock. The contractors for the lock are also constructing this cut-off link. The picture at the right shows two wagon drills starting the excavation for the footings.



lower fifteen miles of this canal was inundated, but the upper section was continued and still is in service although it is entirely inadequate for present-day needs.

Freight movement by way of the river is insignificant, chiefly because of the lack of a continuous deep-draft channel at the low-water stage. From Paducah to Muscle Shoals, roughly 259 miles, the controlling or low-water depth is 4½ feet. Above the shoals it is less, and between Chattanooga and Knoxville, the two principal commercial cities of the valley, it is as little as 1 foot. However, in the opinion of the army engineers who made the extensive investigation referred to in a preceding article, there exists a great and growing tonnage which would utilize water transportation if a 9-foot channel were available throughout the 652-mile stretch from the mouth of the river to Knoxville.

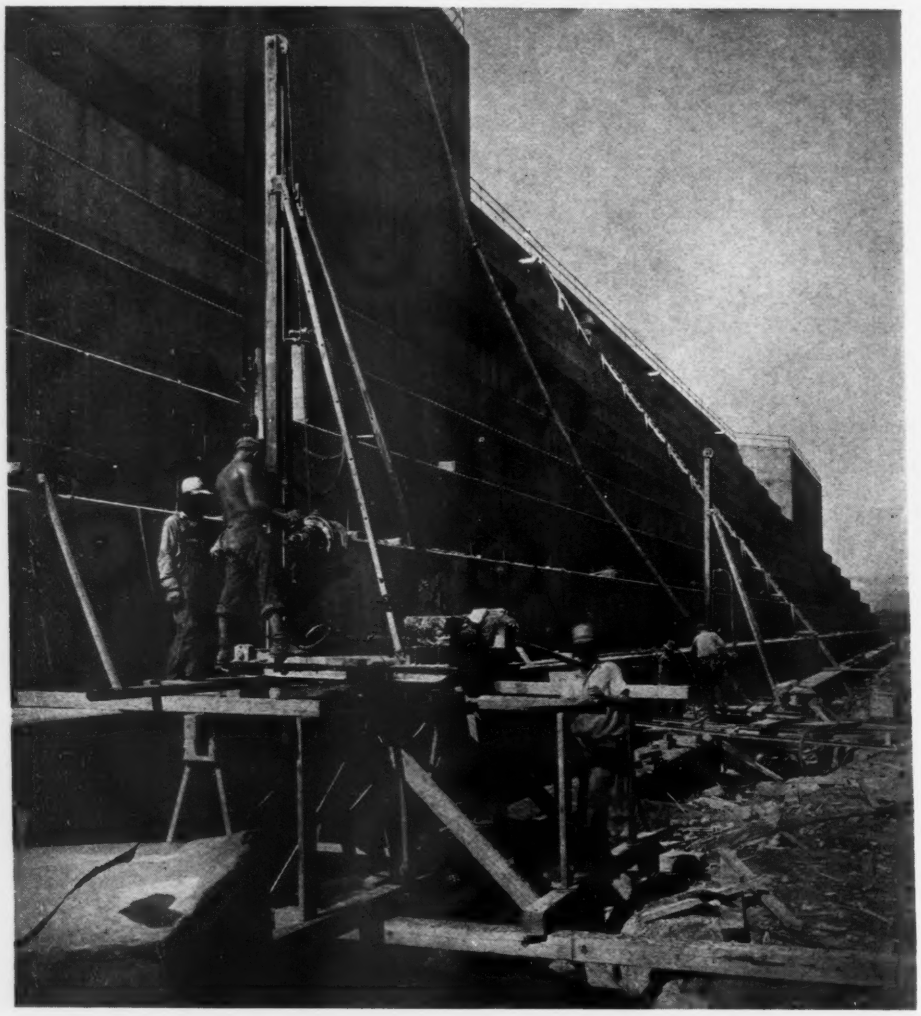
According to this survey, of the 27,584,000 tons of freight that were moved to, from, and across the Tennessee River Basin in 1926, approximately 9,560,000 tons could have been carried more economically by water. Had this been done, an estimated saving of $12,231,000 would have resulted. Actually, only 1,982,252 tons were shipped by water. Although it was admitted that the adoption of waterway transportation would be gradual, it was believed that by 1950—assuming a continuation of the prevailing normal increase in freight traffic in the valley and the availability of a 9-foot channel as far upstream as Knoxville—approximately 17,800,000 tons would be using the river annually. The saving, based on 1926 rates, would amount to $22,800,000. With a 9-foot channel extending upstream only as far as Chattanooga, the predicted tonnage and monetary saving was figured, respectively, at 7,400,000 tons and $9,600,000. These estimates are now considered to be overoptimistic, inasmuch as they were based on a possible saving of $1.31 a ton in favor of shipping by water instead of by rail, whereas the actual saving recorded in recent years on the Ohio River waterway system is but 50 cents a ton. However, substantial potential economies in shipping are indicated even though the foregoing hypothetical figures are discounted by 60 per cent.

In the days before the Civil War there was considerable traffic in both freight and passengers on the river. Cotton boats steamed upstream as far as Muscle Shoals, where they transferred cargoes and passengers around the rapids to smaller vessels above. However, with increased and better railway facilities, the river began to lose out. For the eleven years from 1923 to 1933, inclusive, the total recorded freight movement was 19,592,533 tons, an average of 1,781,114 tons annually. Its average value was less than $5 a ton.

These figures pertain to traffic on the main river below Knoxville. The principal tributaries—consisting of the Holston, French Broad, Clinch, Little Tennessee, Duck, Buffalo, and Hiwassee—carried a total of 160,000 tons during the same period. The report of the army engineers expressed the conviction that, had 6- to 9-foot channels been available on the lower reaches of these streams, the freight moved by them would have aggregated 5,742,000 tons.

The provision of a 9-foot channel from Paducah to Knoxville, which is the indicated aim of the TVA, will require the building of from 7 to 21 dams, depending upon their height. Below Muscle Shoals, two structures—possibly at Aurora and Pickwick Landing—will be necessary. At Muscle Shoals there already are a low dam, with a 10-foot navigation lock, and Wilson Dam which contains two 45-foot-lift locks. The latter dam provides a navigable lake which extends upstream approximately fifteen miles to the point where Wheeler Dam is now taking form. This structure will back up the water for about 80 miles to Guntersville. One high dam or two low ones will suffice to create deep water as far as Chattanooga because of two existing intervening structures, Widow's Bar Dam and Hales Bar Dam, which provide a navigable depth throughout the final 45-mile stretch. From Chattanooga to Knoxville there will be needed four high dams or seventeen low ones. Since the TVA program calls for the use of such structures for both navigation and power purposes, it is likely that high dams, rather than low ones, will be given the preference.

The lock which will become an integral part of the Wheeler Dam is already nearing



CUTTING KEYWAYS FOR THE DAM SECTION
These two X-71 wagon drills are excavating portions of the lock wall so as to assure a firm bond between it and the connecting dam section.

completion. Construction operations there antedated the formation of the TVA—this phase of the development having been inaugurated by the army engineers when it appeared likely that that organization would have supervision of the entire Tennessee River improvement program. Specifications were issued on October 15, 1932, and a contract was let in November, 1932, by the Chattanooga District of the War Department to Stevens Bros. & The Miller-Hutchinson Company of New Orleans, La., which combination was the lowest among eleven bidders.

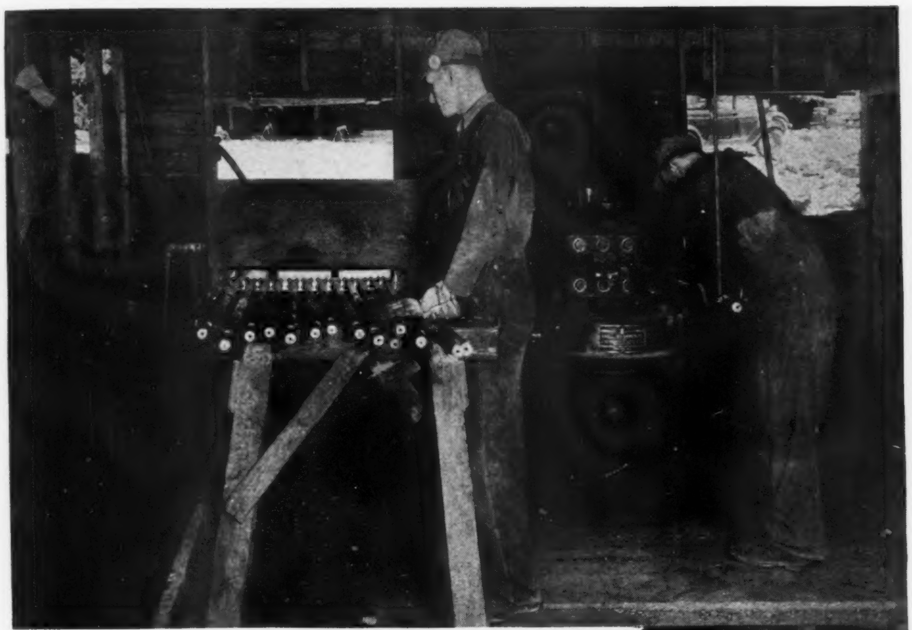
The original plans called for a lock having a lift of 37 feet, this having been the height first set for the dam which was to be built at that point. When the TVA assumed control, it was decided to make Wheeler Dam high enough to raise the water level 50 feet, and changes had to be made accordingly to bring the lock into conformity with this plan. As a result of the modification, the structure will be the highest single-lift lock in the United States. It is being built just below Lock No. 2 of the old Muscle Shoals Canal which was finished in 1890 and is still in limited use. The new lock provides for a chamber 360 feet long and 60 feet wide in the clear. It will have an upper and a lower guide wall, each nearly 400 feet long, on the landward side, and a lower guard wall 200 feet long on the river side. The over-all height of the concrete above the footings is 76 feet.

The scene of this activity is near the north bank of the river directly opposite the point on the south bank where the Government forces have begun on the construction of the dam which will eventually be knitted with the lock. The usual procedure of building a main lock and allowing for the construction later of an auxiliary lock has been reversed in this instance. Between the landward side of the lock and the river bank there is a space of 196 feet, which is designed to accommodate a 600x110-foot lock when increased navigation warrants it. For the time being, this space will be filled by a cut-off dam identical with the nonoverflow section of the Wheeler Dam of which it is to become a part. Bids for the construction of this wall were called for on May 28, 1934, by the War Department, with the same contractors submitting the low figure. As their equipment was already on the ground, an immediate start was made; and at this writing the project is about half completed. The total cost of both the projects is about $1,600,000.

It is expected that the lock will be ready for service by December of this year. It will be used extensively for moving materials for Wheeler Dam to the upstream side of the site. As the dam progresses from the south bank toward the north bank, the river will be confined to a continually narrowing channel and, although gaps will be left in the concrete when the work reaches the spillway section towards midstream, the flow of the water passing the barrier will be too swift to permit maneuvering barges into position for unloading supplies. By using the lock, it will be an easy matter to reach the upstream side of the site where comparatively calm water will be found.

Operations began in January, 1933, with the erection of a conventional Ohio River box type of cofferdam to gain access to the river bed. The normal maximum water depth was around 16 feet, but there was a possibility of it reaching 20 feet in the case of extremely heavy flood, and it was for this reason that a cofferdam of high dependability was selected. As described by Hal W. Hunt, construction engineer in charge for the contractors, an Ohio River box cofferdam consists of a double line of wood sheathing rodded together and filled with earth. Frame bents and waling were assembled to make a skeleton frame, and the rods were placed through the waling on low wood barges. Sections thus built up were then lowered into the water as the barge advanced. The sheathing was attached later. Alluvial material secured near the site of the work was used as fill, being transported on barges to points of placement and there rehandled. Upon being pumped out, the cofferdam inclosure proved to be fairly dry. As unwatering progressed, the dam was strengthened to prevent overturning by piling loose material against its inside walls by means of cranes.

The river bed consists of limestone, which lies in almost horizontal beds. As the site of the lock was in the channel of the river and was kept fairly clear, there was only a small amount of loose material on top of this rock foundation. Footings for the concrete were carried about 8 feet into the limestone with keyways extending deeper. The removal of approximately 32,000 cubic yards of rock was entailed. To provide clean, smooth, unfractured surfaces, all faces against which concrete was to be poured were line drilled and broached, about 33,000 square feet of wall being treated in this manner. The drilling and broaching were done with four Ingersoll-Rand Type X-71 wagon drills mounted on skids and moved as required on rails. Excavated material was loaded into trucks



SUPPLYING THE DRILLS

This type XCB compressor (right) is one of two machines in the stationary compressor plant. A portable unit is also used. Above is a view of the blacksmith shop where drill steels are reconditioned.

by a 1-yard Koehring shovel and disposed of in an area of the river above the lock site. As it was necessary to convey this muck across the navigable channel leading to the old canal, a barge was utilized to form a pontoon bridge which could be quickly removed when required. Compressed air for operating the drills and for other purposes was supplied by a stationary plant containing two Ingersoll-Rand belt-driven compressors—a Type XB 16&10x14 unit, and an XCB 15&9¼x12 machine. A Type 20 portable compressor of 310-cfm. displacement also was in service.

Exploratory drilling showed that the foundation rested upon approximately 10 feet of sound rock. Below this was a 2-inch seam of soft material. To insure its consolidation, grout holes were drilled to a depth of about 20 feet on about 25-foot centers, wagon drills being used for this work. Low-pressure grouting was done through this system of holes.

The concrete was placed in the lock sections in successive monoliths from 30 to 40 feet long and in lifts of from 5 to 18 feet. Conventional braced forms were used in the footings, and four lifts of Blaw-Knox traveling forms were employed above ground. Successive lifts of the superstructure recede from the outside toward the lock face of the walls, giving the effect of steps and providing increased strength in the lower sections where the water pressure will be greatest.

A conventional concrete-mixing plant was used, consisting of three 1-yard Smith tilting mixers set just inside the cofferdam. These were fed with materials by a floating Whirley through two Blaw-Knox bins and weighing batchers. Cement, sand, and gravel were delivered by barge. The sand and gravel were secured by a suction dredge from the river bed 25 miles downstream. These materials were purchased from the Tennessee Valley Sand & Gravel Company. Cement came from the Cape Girardeau plant of the Marquette Cement Manufacturing Company. It was delivered in bulk and pumped by a Fuller-Kenyon compressed-air pump to a bin at the mixing plant. Castings and structural steel supplied by the Treadwell Construction Company also were delivered by water.

The mixed concrete was transported to the forms by trucks, each of which handled two 1-yard bottom-dump buckets at a time. Dumping of the contents of the buckets into the forms was effected by gasoline-driven cranes. When working on the higher lifts, these cranes were mounted on traveling gantrys. In order to obtain smooth concrete surfaces free from marks the forms above the footings were lined with 3/16-inch tempered "prestwood." This eliminated sanding or possibly rebuilding the forms to secure the desired appearance.

The excavating for the footings of the dam section, or cut-off wall as it is termed, is being done in a manner similar to that for the lock. About 3,000 square feet of line drilling and broaching is being done with X-71 drills. The average depth of the foundations is about 5 feet, and the removal of approximately 4,000 cubic yards of rock is called for. The concrete in this section is being placed with no appreciable slump by the use of Viber Company heavy-duty pneumatic vibrators.

Laborers engaged in this work are all residents of the community and are selected by a local registration committee. Conditions were such that the contractors deemed it inadvisable to maintain a camp; and in order that the workers may live at home, buses are operated for their transportation between the working site and Florence, a distance of about 23 miles.

Construction of the lock is under the supervision of the Nashville District of the War Department. Maj. R. R. Neyland is district engineer. Capt. H. D. W. Riley, military assistant, and G. P. Fleetwood, resident engineer, are in immediate charge. H. W. Miller, a member of the firm, is directing the work for the contractors, with J. E. Walters serving as superintendent, A. O. Oberson as general carpenter foreman, and, as mentioned, Hal W. Hunt as construction engineer.

NATIONAL PLANNING

MOMENTOUS events are taking place below the Mason-Dixon Line. They are bound to change the social and economic complexion of the Tennessee Valley, an area almost as large as Pennsylvania. An attempt is made in this issue to give our readers a bird's-eye view of the TVA activities. It can, at best, be no more than a fleeting glimpse, for the ramifications of the movement reach far and wide and the field of view is changing with kaleidoscopic speed. It has been our aim to look more closely at certain constructional phases of the picture and to give an idea of how they fit into the whole mosaic.

No one knows how far the TVA plan will go, nor what its ultimate effect will be upon the lives of Americans. Even its most fervent supporters freely admit that it is an experiment, but they have the courage of their convictions and believe firmly that it will point the way to a more orderly and a more secure existence for several million persons. Already the same scheme is being applied in part in the basin of the Columbia River; and, if the TVA is successful in its broader purposes, we may some day have a nation planned as carefully and as precisely as are Washington and certain other cities whose growth has taken place under the guidance of trained specialists.

The Tennessee River is the fifth largest stream in the United States. We do not have to take the word of one man that the valley through which it runs is potentially one of the richest in the nation. Dr. A. E. Morgan, chairman of the TVA, declares that its natural wealth is being realized only to the extent of 10 per cent of its real value. Col. Hugh L. Cooper, who directed the construction of Wilson Dam at Muscle Shoals, stated in 1925: "Muscle Shoals is the keystone of a vast superpower system that will serve around 12,000,000 people in six states of the South with benefits that can come to them in no other way. If sound engineering can be carried on in a sane manner, the Tennessee River can be rebuilt with wide benefits to navigation and with a power production equal to more than one-fifth of all the hydro-electric power that is now used in the United States, Niagara Falls included."

Briefly, the Government proposes to harness this latent power and, by means of inexpensive electricity, to remold the sphere of activity of the Tennessee Valley inhabitants. Dams are important in the scheme, because it is only by conserving water during dry seasons and making multiple use of it that power can be produced at low cost. Doctor Morgan explains it as follows: "Without suggesting any particular level of unit cost, I venture the opinion that if the water-power development of the entire Tennessee River drainage area of 40,000 square miles can be given a single unified ownership and control, the unit cost of power may be no more than half of what it would be with divided ownership and management. To illustrate: Near the east boundary of Tennessee is a dam site which will provide vast storage capacity for an area of very heavy rainfall and run-off of a few thousand square miles. From this point down the Tennessee River to its mouth is a fall of, roughly, 1,000 feet, nearly all of which can be used for generating power. A plan has been proposed by a private company for generating power at the upper site with a dam, say 200 feet high, and to administer this power plant as an independent industrial undertaking, perhaps for the operation of a large manufactory. If this power plant is operated as an independent unit, it will be built with a view to its own needs. The management cannot invest money on the chance that stored water might on occasion be used by plants down below, in which it has no financial interest." The Government, however, can build interrelated power plants—holding water here and releasing it to the turbines there—and regulate the river flow to the end that virtually every drop of water can be made to produce electricity.

The shaping of things so that there will be a demand for that power is an essential part of the general scheme. We have dwelt but little upon it, believing that our readers are primarily interested in the constructional phases of the program. Suffice it to say that there is keen activity looking towards the desired end. Incidental to the dams there is being provided a series of locks that will make the Tennessee navigable for boats of 9-foot draft as far as Knoxville.

All these things are being done at public expense, so the taxpayer is naturally interested in their cost and whether he stands to get something in return for his money. Doctor Morgan's answer is that he will. He goes further, and says that in his judgment the bill for dam building will be amortized through power sales in 25 years. He asks five years to allow the scheme to gain momentum, after which he predicts that there will be a profit from its operation.

PASS YOUR COPY ALONG

IF YOU do not keep your copies of this magazine after you have read them, why not give them to a high school, Y.M.C.A., public library, or some other institution where boys and young men may see them? The publishers supply free copies to hundreds of such places, but it is obviously impossible to include them all. Many of our readers are already following the suggested practice, and their thoughtfulness is so greatly appreciated that we often receive letters telling us about it.

High-school students, in particular, find material in our pages for essays on a wide range of subjects. Numerous boys are preparing for engineering courses and are keenly interested in the type of articles that we present. Perhaps you have a son who will take your issue to school each month after you have finished with it. If not, telephone the nearest school or other institution that has a library or reading room and arrange to pass your copy along to it.

This and That

They Stuck to Their Guns

The improvements which are now being made in the navigability of the Tennessee River represent a triumph for persistence. In our first article we have told the part which was played by the Tennessee River Improvement Association in focusing the attention of Congress upon the potentialities of the river. Even before the formation of this organization, however, a small band of men had been at work seeking, by example, to demonstrate that the Tennessee watercourse held great possibilities as a carrier of commerce.

At the instance of the *Chattanooga Times*, 100 men were prevailed upon 43 years ago to subscribe $1,000 each towards the establishment of a boat line to ply between Chattanooga and the Ohio and Mississippi rivers. These men knew that they could make no money: their real object was to interest Congress in the development of the river. The Chattanooga Steamboat Company was formed, and the steamboat *Herbert* was purchased and placed in service between Chattanooga and Paducah. The president of that organization was Adolph S. Ochs, present publisher of *The New York Times* who was at that time running the *Chattanooga Times*, which is still owned largely by the Ochs family.

After the *Herbert* had made a few runs it was rebuilt into *The City of Chattanooga*, which was a large vessel for the Tennessee River. It was common knowledge that boating above Florence, Ala., where Muscle Shoals began, was precarious business, particularly in times of low water. The company persevered, however, and *The City of Chattanooga* made a number of trips to the mouth of the Tennessee and even to St. Louis and Louisville. Financially the venture was a failure, but morally a victory was scored when Congress began to take notice of the operations. The company underwent several reorganizations, but it kept going. Throughout its life it had the loyal support of certain shippers in the area. Sometimes their consignments of goods were delayed a month or more in delivery, but they continued to patronize the line, contributing unselfishly to the furtherance of the movement to impress the Government at Washington. Seemingly, the fruits of those manifold efforts are ripening.

* * *

A Lady Asks a Question

THE construction undertakings which are in progress in the Tennessee Valley are objects of great public interest. This is particularly true with respect to Norris Dam, which is easily accessible over good roads from Knoxville. Not only residents of the valley but tourists in the region flock to the scene of operations in great numbers. As many as 10,000 visitors have been counted in the course of a Sunday. There is no air of secrecy about these jobs. On the contrary, the TVA welcomes sightseers, the only restriction being that they must stay out of the danger zone. Fortunately the topography affords excellent vantage points on both sides of Norris Dam. A corps of young men, known as the Guide and Guard Service, is on hand to show visitors about and to answer questions. Needless to say, some of the queries put to them border on the humorous side. According to one member of the guide group, the championship for crazy questions belongs to the kindly faced old lady who, upon viewing the towers which support the cableways used for placing concrete, asked innocently: "Is that the way they will lift the dam to let the boats pass?"

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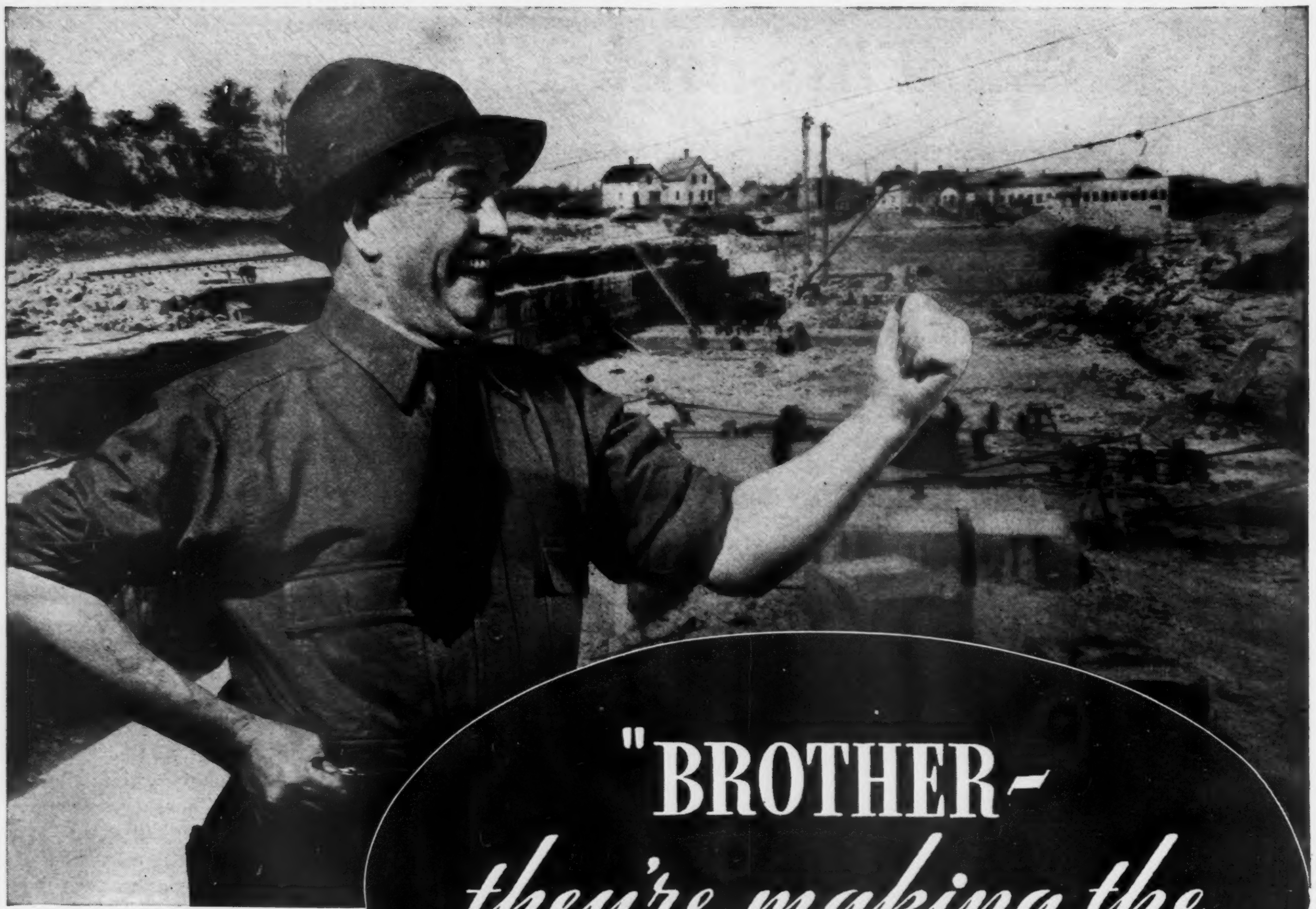
Honoring a Southern Gentleman

DURING the low-flow periods of the Tennessee River there are places in the 37-mile stretch of Muscle Shoals where a man on horseback can cross the stream. On an October afternoon in 1863, several squadrons of gray-uniformed cavalrymen emerged from the woods topping the north bank of the river, plunged down the steep slope into the water, and made their way across. At their head was a 27-year-old Georgian officer, Joe Wheeler. Thirty-five years later, President McKinley summoned to his office a white-haired gentleman who was serving as Congressman and made him a major general in the army that was being organized to evict the Spaniards from Cuba. Joe Wheeler again. It was under him that Theodore Roosevelt and Leonard Wood came into undying fame at San Juan Hill. It was he who arranged the terms of General Toral's surrender, terms which were tempered with mercy. In recognition of his valiant service, a grateful Government commissioned him brigadier general, and he served in the regular army until his death in 1906. His body lies in Arlington Cemetery at Washington. During the interval between the Civil and Spanish wars, General Wheeler had returned to the point where years before he had forded the Tennessee River and married an attractive southern lady whom he had met during a brief stop at a farmhouse on that eventful afternoon. He settled on a nearby plantation, which extended to the river's edge a short distance above the line where the dam which is named for him is now taking form. He served twenty years in Congress, and during that period he was one of the foremost champions of the development of the Tennessee River.

NORRIS DAM ENGINEERS
C. D. Riddle, construction engineer (left), and Barton M. Jones, chief engineer.



"BROTHER- *they're making the rocks fly now!*"

This man found the remedy for a bad nuisance. It will never bother him again.*

"Look at those fellows work! Good men. I should have known that—did know it. Picked 'em myself. But weren't they spoiling my breakfast a couple of weeks ago!

"Every man of 'em 'd tear around at top speed until he picked up a drill. Then he'd settle down to a slow and easy life, half work and half loafing, so it looked to me. I fumed and bit my nails, and a lot of good it did me!

"But fortunately I've got a good repairman—who told me about finding pieces of rubber in the drills. It wasn't the fault of the men at all! I cut off a piece of hose near the compressor and split the end of it. Well, I couldn't have been more surprised if I'd found it full of fleas.

"The rubber looked like dried mud. It crumbled and fell to pieces wherever you touched it. It's the oil acting on rubber. They tell me Goodrich hose doesn't break up that way. Anyway, it didn't take me long to make a big scrap pile out of a lot of old hose. We've got Goodrich hose on all the tools now—and those fellows have made the rocks fly ever since. If that hose stands up like they say it will, we'll never use anything else!"

Goodrich Type 50 air hose NEVER breaks into loose rubber particles. Wouldn't you like to read the whole story, "Effects of Oil on Air Hose," written by the Goodrich technical staff (but in a non-technical way)? It takes only five minutes—an interesting story—and a helpful one to *you* if it leads you to buy Goodrich hose. Ask your Goodrich distributor or address B. F. Goodrich Rubber Co., 136 Falor St., Akron, Ohio.

*The facts on which this story is based were furnished us by a large, well-known buyer of air hose.

Goodrich *Type 50* Air Hose never clogs your tools with rubber!